THE

GEOLOGICAL MAGAZINE

NEW SERIES. DECADE V. VOL. X.

No. VII.—JULY, 1913.

ORIGINAL ARTICLES.

I.—TO THE READERS OF THE *GEOLOGICAL MAGAZINE*.

IT may interest our readers if we remind them that with the publication of our July Number the GEOLOGICAL MAGAZINE enters upon the fiftieth year of its existence. The first number was issued in July, 1864, and the first volume consisted of six numbers for the half-year.[1] Consequently the commencement of the fiftieth volume took place in January of the present year. It must be a matter for congratulation to the Editor that during so extended a period he has personally edited every number, excepting three, when he took a long vacation in Italy and could not conveniently deal with proofs. Such a record is probably unique. It is moreover satisfactory to learn that there has at no time been a serious lack of useful material wherewith to fill the pages of the Magazine. In our copy of Vol. I there are lists of Local and Foreign Correspondents; among the former is the name of the Rev. H. H. Winwood, and among the latter are the names of Baron Adolph von Koenen and Dr. Anton Fritsch. Amongst surviving contributors to the 1864 volume may be recorded the Rev. Osmond Fisher, Sir Archibald Geikie, Professor Edward Hull, Sir E. Ray Lankester, and Henry Woodward.

H. B. W.

II.—ON *SOLENOPORA GARWOODI*, SP. NOV., FROM THE LOWER CARBONIFEROUS IN THE NORTH-WEST OF ENGLAND.

By GEORGE J. HINDE, Ph.D., F.R.S., F.G.S.

(PLATE X.)

INTRODUCTORY REMARKS.

SOME years since Professor E. J. Garwood sent to me for examination some pieces of limestone from the Lower Carboniferous rocks in the Shap and Ravenstonedale districts of Westmorland, in which he had observed the rounded outlines of fossils with a structure which appeared to him to resemble that of *Stromatopora*. The rock in which the fossils were embedded was so compact and hard that they could not be extracted, and it was necessary to make sections in various directions in order to ascertain their structure, which proved to be identical with that of *Solenopora*, now well known as one of the

[1] But the *completion* of the *actual* fifty years (or Jubilee of the GEOLOGICAL MAGAZINE) will not be reached until *June, 1914*.—ED.

calcareous Algæ. It is many years ago since this genus was recognized in the Ordovician rocks in North America, Britain, and Russia; more recently it was found in the Silurian rocks of the Isle of Gotland, and in 1894 a species was described from the Jurassic rocks of Gloucestershire and Yorkshire. But until this fortunate discovery of its occurrence in the Lower Carboniferous by Professor Garwood, no example of the genus was known in any of the rocks between the Silurian and the Jurassic.

I am greatly indebted to Professor Garwood for permission to describe this new and interesting species—which I propose to name after him—and for providing me with numerous specimens and sections for the purpose.

Description.

Form and Mode of Growth.

The thallus of this species grows in small, depressed, nodular masses; in their higher stages lobate extensions are produced, which show a tendency to further division. The specimens measured are from 20 to 26 mm. in diameter and about 14 mm. in height. It is uncertain whether they were attached to other bodies or continued free during their growth. They consist of very compact, hard limestone, of a light greyish-brown tint, resembling that of the matrix in which they are enclosed. In a horizontal section of a specimen which has been figured (Pl. X, Fig. 1) concentric lines or bands of a slightly darker tint are seen at regular intervals extending across the thallus, probably indicating periods of growth.

Character and Arrangement of the Cells.

Thin sections taken in a vertical or radial direction through the thallus of this species show the cells with great clearness. Their longitudinal walls are straight and even, but their transverse walls, though sometimes straight, for the most part are slightly concave; the concavity is towards the upper or growing surface of the thallus (Pl. X, Figs. 3, 6). The cells are closely arranged in vertical and transverse rows, and the partition walls, under low magnification, appear to be simple and imperforate. The vertical rows are generally straight and parallel, but through the intercalation of fresh rows of cells by growth they diverge slightly and have a fan-like appearance. The transverse rows form concentric, evenly arched lines, extending across the thallus.

The cells vary considerably in size and form. Some are quadrate, others oblong, and in others the length is much less than the width. The cells in the same transverse row are usually of a corresponding length or height, and it is frequently noticeable that a series of concentric rows of fairly large cells is succeeded by a series of rows of short cells, and this alternation may indicate periods when the conditions were more or less favourable to the growth of the organism.

Seen in cross-section the cells are closely fitted together, and their outlines are very irregular; some are entirely polygonal, whilst the contours of others are partly polygonal and partly rounded (Pl. X, Figs. 4, 5, 7).

Large cells range from 60 to 80 μ[1] in length and from 53 to 66 μ in width; a cell of average size is 50 μ in length by 40 μ in width, whilst a short cell measured 20 μ in length by 47 μ in width.

I have not seen in this species any of the long narrow cells similar to those forming the hypothallus in recent and fossil species of *Lithothamnion*, nor have I met with any indications of conceptacles or other structures which could be regarded as reproductive organs.

The Structure of the Cell-walls.

As a rule but scanty reference is made to the structure of the cell-wall in descriptions of *Solenopora*, owing to the fact that in ordinary thin sections nothing more is shown beyond a partially opaque line or band, without structure, between the cells. But it has been possible to prepare thin sections from some of these Carboniferous specimens of such extreme tenuity that the partition walls are fairly transparent, and exhibit structural details of considerable interest (Pl. X, Figs. 6, 7).

Under the microscope, with somewhat high powers, in the centre of the wall bounding the cells there is shown a very delicate continuous line, which is, actually, a section of an extremely thin, even, imperforate lamina, which forms a median partition in the wall between contiguous cells. It is present in all the walls of the cell whether longitudinal or transverse; in very thin sections it is translucent and in places of a faint pinkish tint. Measured in section this median partition is between one and two microns in thickness, and thus about one-sixth of the average thickness of the whole wall, which varies between 6 and 8 μ.

This median lamina is markedly distinct in character from the main portion of the cell-wall on either side of it, which is composed of very minute granules of calcite, whereas no constituent particles can be recognized in the median plate.

The outer layers of calcite granules on either side of the median plate are less resistant than the lamina itself, and they are frequently broken up and disappear in the preparation of the thin section, thus leaving the lamina as the only representative of the cell-wall. Usually, however, small portions of the granular layers remain, attached to the median plate. The interior area of the cells is now filled with clear calcite.

I am only aware of two references in the literature relating to *Solenopora* to a median structure in the cell-wall of this genus. The first is in the paper by Nicholson & Etheridge on *S. compacta*, Billings, sp., which appeared in the Geological Magazine.[2] On Pl. XIII, Fig. 7, is represented a transverse section of some cells of *S. compacta* (?) from Saak, Esthonia, which are drawn to the same scale as the Figs. 6 and 7 in the Plate accompanying this paper. The Fig. 7 of the Saak specimen, which was drawn by the late Professor Nicholson, shows a definite dark line in the centre of the wall, which may indicate a median lamina of the same character as that in *S. garwoodi*. No reference, however, is made to it in

[1] μ = micron, $\frac{1}{1000}$ of a millimetre.

[2] Geol. Mag., 1885, p. 529, pl. xiii.

the text of the paper. In Fig. 4 of the same plate a dark line is also shown in the longitudinal walls of a Canadian specimen, but it is much thicker and less definite than in Fig. 7. It happens that Fig. 7 was drawn from a section still in my possession, and the dark line shown in this cannot, in my opinion, be interpreted as representing a median partition in the cell-wall, and it is not referred to as such by the authors[1] of the paper.

The second reference is by Professor Rothpletz,[2] who, in describing a specimen of *S. compacta*, states that the walls show a distinct, dark, median line, which also marks the exact boundary between two contiguous cells. It reminded him of the dark line in corals! It is further stated not to be continuous, but perforated at intervals by very fine pores. I strongly suspect that the dark median line mentioned by Rothpletz is of the same character as that in my specimen figured by Professor Nicholson.

The characters of this species from the Lower Carboniferous fully support the conclusion of Dr. A. Brown[3] that *Solenopora* is one of the calcareous Algæ, and this view is also supported by Professor Seward,[4] who places the genus in the Corallinaceæ.

Distribution.

S. garwoodi was first discovered by Professor Garwood in limestone rocks of Lower Carboniferous age, which, in his elaborate memoir on "The Lower Carboniferous Succession in the North-West of England",[5] he has grouped together as a separate subzone, with the present species as the index-fossil, and given it the name of the '*Solenopora*' subzone. The fossils are met with at the Abbey Cliff, Shap District; Stonegill in the Ravenstonedale District; and Low Meathop in the Arnside District; and also at other localities in Westmorland.

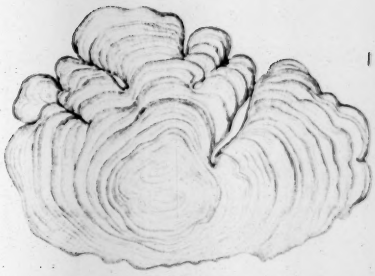
EXPLANATION OF PLATE X.

Solenopora garwoodi, Hinde.

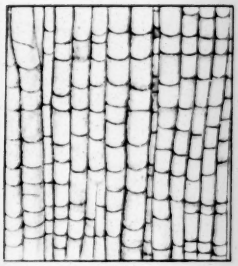
Fig. 1. A horizontal section of a nearly complete specimen showing concentric bands of growth. × 2 diams.
,, 2. A radial section of a specimen from Shap Abbey, showing the close arrangement of the cell-rows. × 50.
,, 3. A similar section from Meathop. × 50.
,, 4. A transverse section of a specimen from Meathop, showing the cells. × 50.
,, 5. A transverse section of a specimen from Stonegill. × 50.
,, 6. A radial section of a specimen from Shap Abbey, showing the structure of the cell-walls. × 150.
,, 7. A transverse section of a specimen from the same locality, showing the structure of the cell-walls. × 150.

All the specimens are from the *Solenopora* subzone of the Lower Carboniferous.

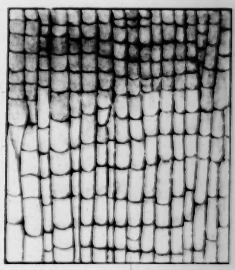
[1] Geol. Mag., 1885, p. 533.
[2] Svenska Vetensk. Akad. Handl., Bd. xliii, No. 5 (1908), p. 12, pl. 3, figs. 1–6.
[3] Geol. Mag., 1894, p. 203.
[4] *Fossil Plants*, vol. i, p. 190, 1898.
[5] Quart. Journ. Geol. Soc., vol. lxviii, pp. 449–586, 1912.



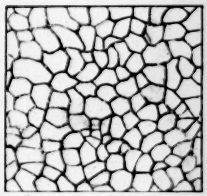
1



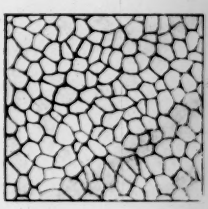
2



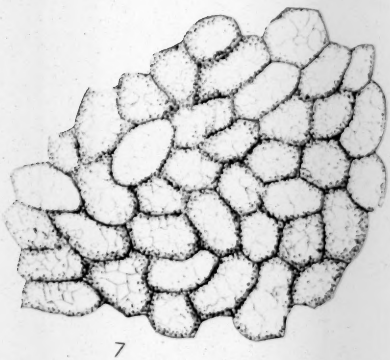
3



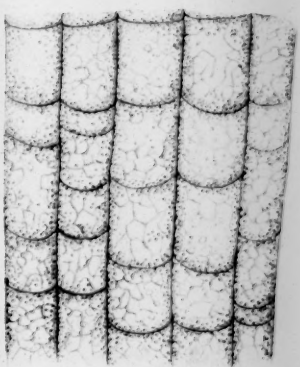
5



4



7



6

W. M. Woodward & G. J. Hinde del.

SOLENOPORA GARWOODI, Hinde.

Fig. 1, × 2; Figs. 2–5, × 50; Figs. 6, 7, × 150.

III.—The Position of the Merostomata.

By Henry Woodward, LL.D., F.R.S., F.G.S.

MORE than fifty years since a great impulse was given to the study of a new and strange group of Palæozoic Arthropoda whose remains were almost simultaneously brought to light in New York, in England, Scotland, and in the Baltic island of Oesel, and attracted the attention of numerous palæontologists both in this country and in America. Among others may be cited Hugh Miller and the elder Agassiz, who at first believed them to be fish (1844), but the latter afterwards was convinced that they were in reality the remains of an enormous Crustacean.

Professor M'Coy gave a weird restoration of *Pterygotus problematicus* in the 5th edition of Lyell's *Manual of Elementary Geology* (1855, p. 420).

Further discoveries of *Pterygotus* made by Mr. Robert Slimon, on the banks and bed of Logan Water, Lanarkshire (1855), were examined by Professor Huxley and Mr. J. W. Salter, and led to the production of a Geological Survey memoir in 1859, illustrated by sixteen folio plates and many text-figures.

Mr. J. W. Salter contributed a restoration of *Pterygotus anglicus* to Murchison's *Siluria* (1859 edition), in which, although happier than M'Coy's figure already referred to, he gives only two pairs of appendages to the head; the thoracic plate, or operculum, is placed *in front* of the mouth, and the lower lip or metastoma is absent.

In the same year a Russian naturalist, Dr. J. Nieszkowski, published an account of *Eurypterus remipes* from the Upper Silurian in the Island of Oesel, Baltic, giving restorations of the upper and under sides of *Eurypterus*, showing the appendages of the mouth in situ and the thoracic plates on the under side of the body immediately behind the mouth.

Following after Salter, Mr. David Page, in his *Advanced Text-Book of Geology* (1859), gives restorations of several forms of *Pterygotus*, *Stylonurus*, *Eurypterus*, etc., all more or less correct, but without descriptions.

Professor James Hall, the veteran geologist of the Albany Museum, was the author of a most valuable monograph (1859–60) giving excellent descriptions and figures of the American species of *Eurypterus* and *Pterygotus* (see his *Palæontology of New York*, vol. iii, pt. i, pp. 382–419*, 80 plates and 10 additional plates), the accuracy of which still remains unchallenged.[1]

In 1862 and 1863 Mr. J. W. Salter contributed descriptions of *Eurypterus* and allied forms of *Pterygotus* (Quart. Journ. Geol. Soc.).

The writer figured and described a very complete example of *Slimonia acuminata* from the Upper Ludlow rocks of Lesmahagow, Lanarkshire, in the *Intellectual Observer*, 1863 (vol. iv, No. iv, pp. 229–37), and of *Eurypterus lanceolatus* (in the Geol. Mag. for 1864, Vol. I, p. 107, Pl. V, Figs. 7–9). In 1865 he figured and described *Stylonurus scoticus*, *Stylonurus Powriei* from the Old Red of Forfarshire, and *Stylonurus Symondsi* from Herefordshire, also

[1] Thirty quarto volumes have been published by the New York State Museum, fourteen of which, on Geology and Palæontology, are by James Hall.

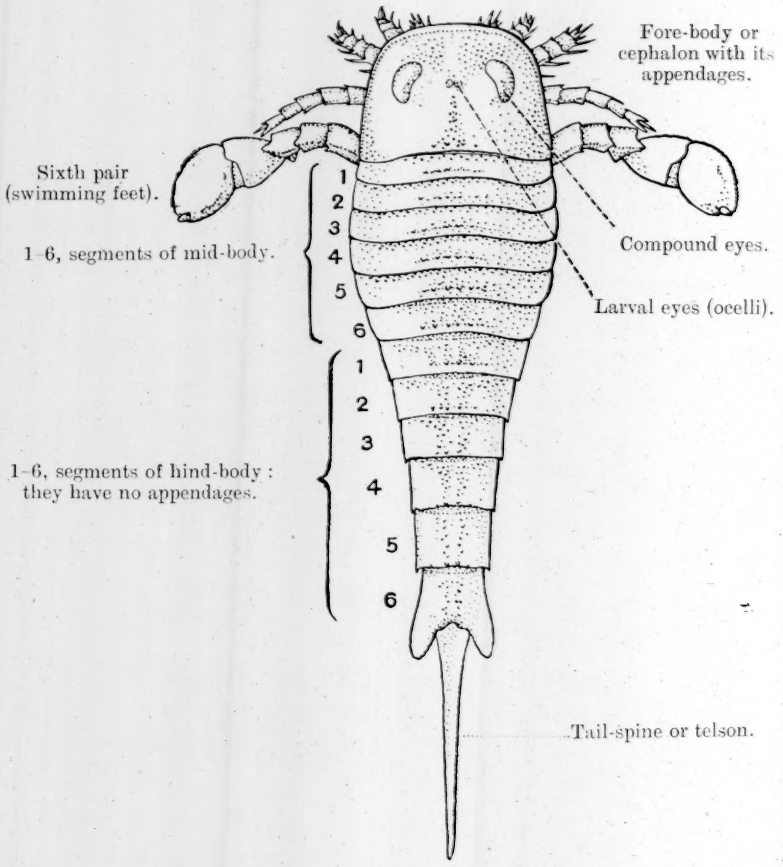


FIG. 1. Upper or dorsal aspect of *Eurypterus Fischeri*, from the Upper Silurian of Oesel in the Baltic. The drawing made from G. Holm's original figure. Nat. size. Reproduced by permission of the Trustees of the British Museum (Natural History).

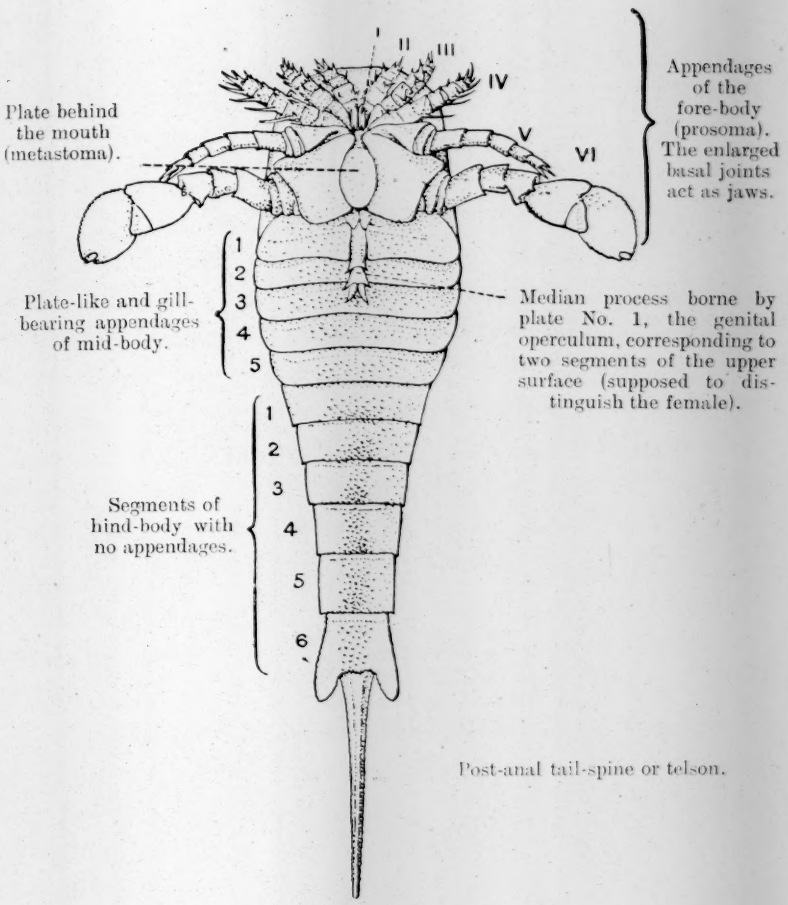


FIG. 2. Lower or ventral aspect of *Eurypterus Fischeri*, from the Upper Silurian of Oesel in the Baltic. The drawing made from G. Holm's original figure. Nat. size. Reproduced by permission of the Trustees of the British Museum (Natural History).

Hemiaspis limuloides from the Lower Ludlow, Shropshire (see Quart. Journ. Geol. Soc., vol. xxi, pp. 482–92, pls. xiii, xiv).

In 1866 I commenced a monograph of the British Fossil Crustacea of the order Merostomata in the annual volumes of the Palæontographical Society, completed in 1878, in which fourteen genera and eighty-three species are recorded and all the then known British species described and figured.

From 1878 to 1911 more than a hundred contributions have been added to our knowledge of this truly wonderful group.

Special reference should be made to the remarkable work of G. Holm[1] on *Eurypterus Fischeri* from the Upper Silurian of Root-si-kul, in the Baltic island of Oesel. Professor J. M. Clarke writes: "Taking for the subject of his investigations the same *Eurypterus fischeri* from Oesel, that had been already studied by Nieszkowski and Schmidt, he succeeded by most clever manipulation in isolating the chitinous test of the animal, which in this locality is not metamorphosed into a carbonaceous film, as in other deposits, and was able to elaborate its organization in such detail that *E. fischeri* has really become the most completely known of all extinct animals, and our exact knowledge of it is quite comparable with that of its recent relatives.

"By comparison with *Limulus*, the differences in the appendages of the first and second sternites were referred to their proper sexes. Many details of structure were discovered, such as the minute cheliceræ, the epicoxite of certain coxal segments, the endostoma of the posterior margin of the mouth, the connection of the metastoma with the gnathobase, the clasping organ of the second endognathite of the male, the originally composite nature of the metastoma, corresponding to the chilaria of *Limulus*, and the interior tubular processes of the female opercular appendage. His work has served to bring out with still greater force the numerous homologies and consequent close relationship of the Eurypterids to *Limulus*."

Figs. 1 and 2 give actual reproductions of this remarkable specimen, showing the dorsal and ventral aspect (pp. 294–5).

To those who are interested in the study of these ancient forms, it may be desirable to mention that a model of *Eurypterus Fischeri* (by Mrs. Blackman) is exhibited in the Zoological Gallery of the Natural History Museum, Cromwell Road, S.W.

Foremost of the long list of modern investigators, and following, as Director of the New York State Museum, in the position so long and honourably held by Professor James Hall at Albany, N.Y., stands the name of Professor John M. Clarke, Ph.D., D.Sc., LL.D., For. Corr. Geol. Soc. Lond., and one of the most able and energetic geologists and palæontologists in North America.

Assisted by Dr. Rudolph Ruedemann, Professor J. M. Clarke issued last year (1912) from the State Museum, Albany, two grand volumes entitled Memoir 14, *The Eurypterida of New York* (one volume of text, pp. 440 quarto, with 121 text-figures, and one volume of 88 plates, several of which are large folding plates, and pp. 441–628,

[1] "Ueber eine neue Bearbeitung des *Eurypterus Fischeri*, Eichw.": Acad. Imp. Sci. Bull. St. Pétersbourg, sér. v, iv, 369, 1896; Geol. For. i Stockholm For., Bd. xxi, p. 83, 1899.

of explanations of plates, with a full index at the end). It is delightful to find in these massive tomes such a grand collection of materials relating to the American Merostomata, which the authors have themselves brought together so carefully and studied and described with so much patience and acumen, nor has the contemporary foreign literature on the group been neglected, for every writer will find his work and observations duly recorded and acknowledged.

The volumes just issued by the New York State Museum make us acquainted with no fewer than sixty-six American species, ranging from Professor Walcott's *Beltana Danai*, *Echinognathus Clevelandi*, and *Strabops Thatcheri* of Cambrian age to the *Eurypteri* of the Coal-measures. No *Limuli* are recorded, but they are accepted as next of kin to the Eurypterids on the one hand and to the Scorpions on the other.

Of actual *complete* forms of *American* Eurypterids known and figured by Clarke and Ruedemann in their memoir (vol. ii), may be cited—

Strabops Thatcheri, Beecher. Upper Cambric.
Eurypterus remipes, De Kay. Siluric.
E. lacustris, Harlan. Bertie Waterlime.
E. ranilarva, Clarke. Lockport Limestone.
E. Dekayi, Hall. Waterlime.
E. microphthalmus, Hall. Manlius Limestone.
E. Maria, Clarke. Shawangunk Grit.
E. Kokomoensis, Miller & Gurley. Waterlime.
Eusarcus scorpionis, Grote & Pitt. Waterlime.
E. Newlini, Claypole. Waterlime. (Size, 26 × 13 inches.)
Dolichopterus macrocheirus, Hall. Waterlime.
Stylonurus longicaudatus, Clarke. Waterlime.
S. excelsior, Hall. Catskill Beds. (56 inches long.)
S. cestrotus, Clarke. Shawangunk Grit.
S. myops, Clarke. Shawangunk Grit.
Hughmilleria socialis, Sarle. Pittsford Shale.
H. Shawangunk, Clarke. Shawangunk Grit.
Pterygotus Buffaloensis, Pohlman. Bertie Waterlime.
P. macrophthalmus, Hall. Bertie Waterlime.

To these must be added nearly fifty species described and figured from more or less perfect remains, many of which, however, add greatly to our knowledge of structural details of the group.

The plates are admirably executed and show the minutest features of each species. The eighty-eighth and last plate gives an enlarged figure (× 7) of *Proscorpius Osborni*, Whitfield, Upper Silurian, affording a convenient comparison with *Eurypterus* and other Merostomes.

The following fifty species are arranged in order from the Cambrian to the Coal-measures:—

Beltana Danai, Walcott. Greyson Shales, Montana.
Echinognathus Clevelandi, Walcott. Utica Slate, Oneid Cap.
Eurypterus megalops, Clarke. Frankfort Shale.
E. pristinus, Clarke. ,,
E. stellatus, Clarke. ,,
Eusarcus triangularis, Clarke. ,,
E. (?) *longiceps*, Clarke. ,,
Dolichopterus frankfortiensis, Clarke. ,,
D. latifrons, Clarke. ,,
Hughmilleria magna, Clarke. ,,

Pterygotus nasutus, Clarke. Frankfort Shale.
P. prolificus, Clarke. ,,
Stylonurus (?) *limbatus*, Clarke. ,,
Megalograptus Welchi, Miller. Richmond Group.
Eurypterus prominens, Hall & Clarke. Clinton Beds.
E. sp. Arisaig, Nova Scotia.
Drepanopterus longicaudatus, Clarke. Lockport Limestone.
Eurypterus Boylei, Whiteaves. Elora, Ontario.
E. Pittsfordensis, Sarle. Pittsford Shale.
Stylonurus multispinosus, Clarke. Pittsford Shale.
Hughmilleria socialis, var. *robusta*, Sarle. Pittsford Shale.
Pterygotus Monroensis, Sarle. Pittsford Shale.
Eusarcus cicerops, Clarke. Shawangunk Grit.
Dolichopterus otisius, Clarke. ,,
D. stylonuroides, Clarke. ,,
Stylonurus cestrotus, Clarke. ,,
S. sp. α, sp. β, sp. γ. ,,
S. sp. ,,
Pterygotus globiceps, Clarke. ,,
Eurypterus lacustris, var. *pachychirus*, Hall. Bertie Waterlime.
E. pustulosus, Hall. Bertie Waterlime.
Dolichopterus siluriceps, Clarke. Bertie Waterlime.
D. testudineus, Clarke. ,,
Pterygotus Cobbi, Hall. ,,
P. grandis (Pohlman). ,,
P. Atlanticus, Clarke. Devonic.
P. sp. ,, Gaspé, Quebec.
Eurypterus pulicaris, Salter. ,,
Eurypterella ornata, Matthew. ,, New Brunswick.
Stylonurus (?) *Wrightianus* (Dawson). Portage Sandstone.
S. Beecheri, Hall. Catskill Beds, Penn.
Eurypterus approximatus, Hall & Clarke. Waverly Beds.
E. Mazonensis, Meek & Worthen. Coal-measures.
E. Mansfieldi, C. E. Hall. Coal-measures, Penn.
E. Pennsylvanicus, C. E. Hall. ,,
E. potens, C. E. Hall. ,,
E. stylus, J. Hall. ,,

Since the important contributions made to this group by Professor James Hall (1859–62) all zoologists have accepted the correctness of his correlation of *Limulus* with *Eurypterus*, *Pterygotus*, and their allies. But another question was raised by Sir E. Ray Lankester (in 1881)[1] as to whether *Limulus* was indeed a true Crustacean after all, but should be rather considered as an aquatic Arachnide.

If we make a brief comparison of the characters of the three great groups of Limulidæ, Eurypteridæ, and Scorpionidæ, we shall be struck by the family resemblances they offer.

In *Limulus* the body, although compressed, represents by its paired appendages the concealed presence of a common number of coalesced segments. The head-shield bears upon its upper surface both ocelli and compound eyes. On the under side is the mouth with six pairs of chelate appendages, the bases of which serve as mouth organs (save the first pair) and for prehensile or walking-legs at their distal extremities. The mid- and hind-body are coalesced and bear on the under side six broadly expanded and united pairs of plates, the first pair carrying the ovaries and genital pores, the five pairs following

[1] "*Limulus* an Arachnid?": Quart. Journ. Micr. Sci., N.S., xxi, p. 609.

being gill-bearing (branchiæ). The hind-body has no limbs, but to it is articulated a long bayonet-shaped tail-spine (or 'telson').

In *Eurypterus* the head-shield is smaller than in *Limulus* and the body much more elongated and the segments free and movable. The head-shield bears upon its upper surface both ocelli and compound eyes. On the under side is the mouth with six pairs of chelate or simple maxillipeds, the first two pairs serving as tactile organs (cheliceræ and antennæ), then three simple spinose limbs, and lastly a pair of larger swimming appendages with well-developed basal jaws and a central oval plate or metastoma. The mid- and hind-body are not coalesced (as in *Limulus*), but the segments are distinct and flexible and adapted to a swimming existence. On the under side, immediately behind the head (as in *Limulus*), is a broadly expanded plate, the operculum carrying on its inner surface the paired ovaries and genital pores, followed by three or more broad plates carrying the gill-packets or branchiæ. The hind-body is destitute of appendages, but to its last segment is articulated a long and slender telson or tail-spine, which in *Pterygotus* is broad and spear-shaped at its extremity.

In *Scorpio* the head is oblong in form and bears on its upper surface ocelli in the centre and groups of eyes at the anterior angles. On the under side is the buccal orifice with short cheliceræ in front, and a pair of large chelate pedipalps, followed by four pairs of simple or clawed oral appendages, used in terrestrial locomotion in the living species, and for assistance in swimming in some of the fossil aquatic forms. The mid-body bears a pair of comb-like organs, and also the organs of reproduction (genital openings). The segments following carry three or more pairs of gill-packets or tracheal openings (respiratory organs) adapted for terrestrial existence in the living species, and for aquatic life in the early fossil forms. The six following segments forming the hind-body are narrow and elongated without appendages; to the last segment is articulated the 'telson' or tail-spine, which in modern Scorpions serves as a sting or poison-organ.

We know that *Limulus* has always been aquatic in its habit, and in the earlier forms the segments of the mid- and hind-body apparently were mostly free and movable, and adapted for swimming, as is the case with the young stages in the development of the living king-crab.[1] It is the opinion of Lankester, of Pocock, of Laurie, and others that the early Silurian Scorpions (*Palæophonus*, *Proscorpius*, etc.) were aquatic forms, their remains having been found in truly marine deposits.

The correlation of *Limulus* with such forms as *Eurypterus* and *Pterygotus* naturally suggested a close affinity with the Scorpionidæ, and it is also of interest to note that Scorpions have been met with in America, in Scotland, and in the Baltic area in marine strata associated with *Eurypterus*, *Pterygotus*, and *Limulus*. It is an astonishing fact that two of these types, *Scorpio* and *Limulus*, should have persistently survived through all the accidents and changes of living things, from Silurian times to the present day, and that both

[1] See A. S. Packard, "Development of *Limulus polyphemus*" (Mem. Boston Soc. Nat. Hist., 1870, p. 154); Anton Dohrn, Jenaische Zeitsch., v, p. 6, 1871; A. Agassiz, Amer. Journ. Sci., ser. III, xv, 75, 1878.

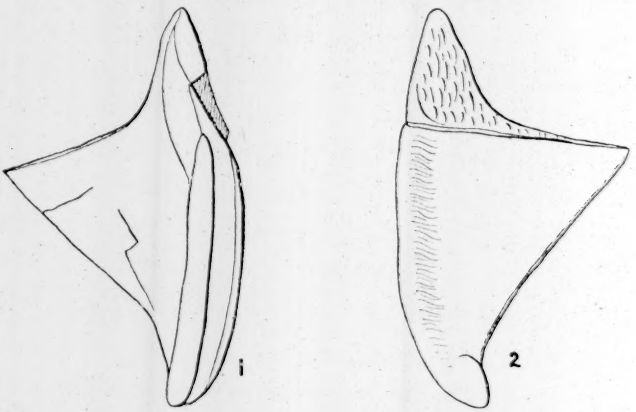
should be found distributed over so vast a geographical area among the living fauna of our globe. They may indeed justly claim to be considered as amongst the oldest living races and the marvels of the animal world.

It is true that the other great group to which they are so closely related, the Eurypterida, has passed away, not having survived beyond the Carboniferous epoch; but as this group certainly appeared earlier on life's scene, it doubtless impressed its mark upon other types of Arthropoda, and quite possibly was the great ancestor of the Scorpions and King-crabs in earlier Cambrian times.

IV.—The Lantern of *Perischodomus*.

By Herbert L. Hawkins, M.Sc., F.G.S., Lecturer in Geology, University College, Reading.

SOME years ago Mr. D. M. S. Watson and I collected, from the Carboniferous Limestone of Clitheroe, Lancashire, a considerable series of Echinoids. One slab of the limestone (measuring 16 × 12 cm.) is covered by a great number of disjointed plates and other skeletal fragments of a large *Perischodomus*, probably *P. biserialis*, M'Coy. Dr. R. T. Jackson refers to the specimen (*Phylogeny of the Echini*, p. 406), and, as the jaw fragments show features not hitherto



Figs. 1, 2.—*Perischodomus biserialis* (?). Alveolar and interpyramidal views of maxillæ.

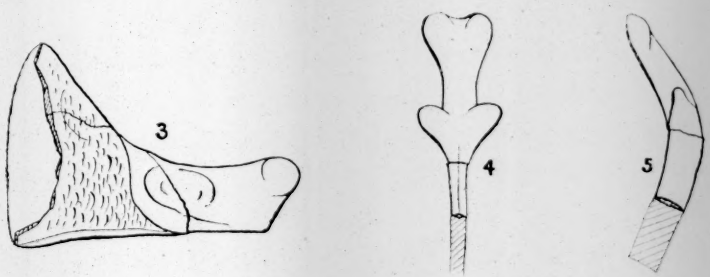
described for the genus, it seems advisable to give a brief account of it. The preservation of a compass is a point of special interest, as these delicate structures are known in very few cases in the fossil state.

Maxillæ (Figs. 1, 2).—Fragments of eight of the ten maxillæ are preserved, three of them being very well shown. The two figured examples show the interpyramidal and alveolar surfaces completely. They agree absolutely in measurements, as do all the other fragments as far as can be ascertained. Symphysial margin 16, dental slide 16,

total length 24·4, greatest width (margin of epiphysis) 12·3 mm. As is usual among Palæozoic lanterns, the maxillæ are very wide (measured radially) and have the interpyramidal faces considerably curved. The convexity of the outer surface (at the symphysis) is such that the tooth must have projected almost at right angles to the line of the upper part of the pyramid—perhaps working horizontally. None of the specimens show the outer face completely, but the indications point to its being similar in proportions to that of *Archæocidaris nerei* (cf. Jackson, op. cit., pl. x, fig. 6).

Epiphyses (Fig. 3).—Two of these ossicles are shown, one being almost complete and exposed from the side of its articulation with the maxillæ. Its radial width is 12·2 mm., and its height at the outer edge is 10·4 mm. Its inner height is only 4·2 mm. There is a slight concavity on the free part of the surface, and a very low knob at the inner and upper corner. The articulation surface is irregularly and coarsely roughened.

Compass (Figs. 4, 5).—One compass exists on the slab, exposed from the side and upper surface. It is broken, apparently along the



Perischodomus biserialis (?).

FIG. 3. Epiphysis, articular surface.
FIGS. 4, 5. Compass, upper and side views.

suture by which all compasses are traversed, and has been pressed into one of the interambulacral plates. A scar is left on the plate where the compass has been destroyed, and this additional part is indicated on the figures by shading.

The total length, as far as can be ascertained, is 10·5 mm. (measured along the chord). From the outer-muscle prominence to the circular-muscle prominence is 4 mm. From the outer extremity to the fracture (? suture) is 6 mm. The height at the inner (broken) end is 2·4 mm. The compass is flattened and broad (viewed from above) in the outer part, but inward from the cross-fracture becomes compressed and narrow. This feature has probably been exaggerated by crushing.

The bifurcation of the outer end is not very marked, although the prominences project laterally to a considerable amount. The most striking features in the compass are the supports for the circular muscle. These project even further outwards than the external supports, as shown in Fig. 4. As far as I am aware, no such

prominence in this region of the compass is met with in any other Echinoid, fossil or recent—in fact, the usual articulation for the circular muscle is rather a depression than an elevation. The compass of *Pholidechinus* (Jackson, loc. cit., pl. xxvii, fig. 5) shows nothing comparable, but is not very perfectly preserved. That of *Archæocidaris rossica* (loc. cit., pl. xii, figs. 1, 2) is particularly slender and smooth in outline.

The precise function of the circular muscle is not known. It is therefore idle to speculate as to the reasons for this extraordinary development in the compass of *Perischodomus*. It suffices to record that it is unique among known forms.

Tooth.—A small fragment of the distal end of a tooth is shown on the specimen. It is 5·8 mm. long (as far as exposed), and 4·25 mm. broad before it begins to taper. It is, as usual, Aulodont in character, and the groove is shallow. The point is broken away.

The specimen is now in the Manchester Museum, registered No. L. 8722.

V.—*Helminthochiton æquivoca*, n.sp., Lower Ordovician, Bohemia.

By Guy C. Robson, B.A.

(Published by permission of the Trustees of the British Museum.)

THE species described in this paper is based on specimens acquired for the Geological Department of the British Museum in 1912 from Professor C. Klouček, of Prague, who collected them from the upper portion of $D_1\gamma$ (=Arenigian) at Sárka and Malé Prilepy. The fossil was referred in the first instance by Professor Klouček to "Chiton sp.?" and the result of the present investigation has been to uphold the reference to the Polyplacophora, though the precise generic status must remain vague.

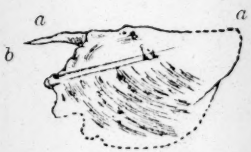
The remains themselves consist of a number of imprints of shell-fragments in portions of two separate ironstone nodules, and have been studied by means of gutta-percha squeezes. In the nodules the imprints are arranged in a crude linear series of indeterminate form, while several of them lie apart from the main series. Two only have the appearance of being applied to one another in the characteristic Chiton fashion. A large number of the fragments are too amorphous to justify the expenditure of time in studying them. We therefore direct attention to six pieces, the shape and texture of which are sufficiently well characterized to enable one to form an opinion of their nature. These, however, are in no case connected with each other, nor do they afford any grounds, save those of general resemblance, for referring them to the same individual.

A typical fragment would consist of a single plate bent into halves, at an angle of 90° or less, along a line occupying the sagittal axis. At their line of junction the two halves form a sharp carina, while at one end of the plate the outer angles of the sides are produced, leaving a median V-shaped notch or emargination. There is probably a corresponding median projection at the other end, but of this it is impossible to be certain. On the surface of the plates a diagonal

sculpture is seen extending as two or three faint grooves from the carina at one end to the free angle at the other (emarginate) end. Under a moderate power of the microscope, but scarcely visible with a hand lens, a faint concentric striation, like growth-lines, is visible running parallel to the outer margins. The valves themselves are very small, a typical example measuring 5 mm. along the carina, and 3·5 mm. from the carina to the inferior free border.

It is impossible to distinguish any other characters than these. Thus it will be seen that the data available for determining the nature and affinities of this fossil are very scanty. The bent plates with diagonal and concentric sculpture suggest a Chiton more than any other form, and we shall see that one character at least—the (posterior) emargination—suggests a definite genus of Chiton. One or two of the plates look superficially like the carinals of an unornamented Cirripede, though there is nothing beyond the carination to endorse this view, and Messrs. Cowper Reed and Withers have not upheld it after examining the specimens.

2.



1.

3.

Helminthochiton æquivoca. × 6. Lateral view of plates. *a*—*a*, median line; *b*, the posterior emargination.

Reference to the literature of Ordovician and Silurian invertebrata has yielded only one genus to which this fossil might be referred, viz. Salter's *Helminthochiton* (1846–7) as redefined by de Rochebrune (1883). Through the kindness of Mrs. Robert Gray and Dr. R. F. Scharff it has been possible to make a careful study of *H. grayiæ*, Woodward (1885), from the Starfish Bed of the Drummuck group of Girvan (Ashgillian age), and of *H. griffithii*, Salter, from the Silurian (Upper Llandovery) mudstones of Galway. The type of the latter from the National Museum, Dublin, was lent by Dr. Scharff, while ample material representative of the former was lent by Mrs. Gray.

The Bohemian fossil seems to be adequately distinguished from the Girvan form. The only feature in common between them is

the nature of their sculpture. But while in *H. grayiæ* both the concentric and diagonal markings are prominent and clearly defined, in the Bohemian form they are very faint and almost imperceptible, and withal very different in character. Indeed, with regard to *H. grayiæ*, Mr. Cowper Reed's doubts (1907) as to its true zoological position seem fully justified, and one would not be in any way surprised if it were to be at a future date removed from the Amphineura altogether.

On the other hand, there is a significant point of agreement between the Bohemian fossil and *H. griffithii* in the (posterior) excavation above alluded to. In addition the valves are short and deep in both species. On these grounds the new form may provisionally be placed in the same genus as *H. griffithii*. It is distinguished from that species by the possession of concentric and diagonal sculpture, and the more acute angle which the two halves of each plate form with each other.

So far as I can discover, no Chiton has been recorded from the Lower Ordovician before. Billings' problematic *Chiton canadensis* (1865) is apparently the oldest-known member of the family up to the present. This form was obtained from the Black River Limestone of Llandeilian age (= Middle Ordovician). If *H. æquivoca* should retain the classificatory position here assigned to it, it will rank as the oldest-known representative of the Amphineura.

The early Palæozoic Chitons would appear to have been small animals, possessed of an armature of thin valves, probably lacking insertional laminæ. In addition some of them were devoid of sculpture on most of their valves, while others (*canadensis*, Billings, the Silurian *bohemica*, Barrande, and the present one) were adorned at least with a sculpture of fine striæ. Differentiation into dorsal and lateral areas was scarcely marked, and a well-developed carina was probably present.

In conclusion, the author wishes to express to Dr. F. A. Bather, F.R.S., and Mr. F. R. Cowper Reed his acknowledgment of their valuable assistance.

Helminthochiton æquivoca, n.sp.

Valves minute, strongly carinate in the median line, (posteriorly) markedly emarginate, lacking insertional laminæ, subquadrate. Sculptured with two or three diagonal grooves, and with numerous fine concentric striæ running parallel to the free edges. Lower Ordovician, $D_1\gamma$ (= Arenigian), of Bohemia. Holotype in the Geological Department of the British Museum (G 22212), from Malé Prilepy. Paratype (G 22213) from Šárka.

PAPERS REFERRED TO.

J. BARRANDE, *Syst. Silur. de la Bohême*, vol. iii, p. 175, 1867.
E. BILLINGS, *Palæozoic Fossils of Canada*, Ottawa, 1865, p. 394.
A. T. DE ROCHEBRUNE, Ann. Sci. Géol., vol. xiv, pp. 1–74, pls. i–iii, 1883.
F. R. COWPER REED, GEOL. MAG., 1907, pp. 108–15.
J. W. SALTER, in Griffith & M'Coy, *Silurian Fossils of Ireland*, Addenda, 1846, p. 71.
—— Quart. Journ. Geol. Soc., vol. iii, pp. 48–52, 1847.
H. WOODWARD, GEOL. MAG., 1885, pp. 352–8.

VI.—The Petrology of Arran.

By G. W. Tyrrell, A.R.C.Sc., F.G.S., Assistant to the Professor of Geology, University of Glasgow.

1. The Riebeckite-orthophyre of the Holy Isle.—Four occurrences of acid and sub-acid igneous rocks containing the rare soda-amphibole riebeckite have been recognized in Great Britain, of which that of Ailsa Craig is the best known. The occurrences of Ailsa Craig[1] and Mynydd Mawr, Carnarvonshire,[2] are riebeckite-microgranites or paisanites. They contain ragged moss-like areas of riebeckite, together with microphenocrysts of quartz and alkali-felspar, in a microcrystalline groundmass of quartz and felspar. Riebeckite was also found by Dr. Teall in the granophyre of Meall Dearg and the neighbouring area of Druim an Eidhne, Skye.[3] Harker described the riebeckite in these rocks as occurring in two forms, one having the usual ragged, sponge-like appearance, and the other being idiomorphic, the faces in the prism zone being well-defined, but with irregular terminations.[4] The fourth occurrence differs somewhat from the others. This rock occurs as an intrusion into the Upper Old Red Sandstone, or Calciferous Sandstone of Easter Eildon Hill, Melrose, and was described by Barron as riebeckite-trachyte or phonolite.[5] It consists principally of sanidine, occurring both as microphenocrysts and in the groundmass, with interstitial patches of riebeckite, and a little nepheline. Harker describes the rock as an orthophyre.[6]

It is interesting to be able to add a fifth occurrence of a riebeckite rock in the so-called felsite of the Holy Isle, near Lamlash, Arran. It is noteworthy that Ailsa Craig is only 18 miles from this locality. The Holy Isle forms a steep and rugged conical hill rising to a height of 1,030 feet, and fitting, so to speak, at a distance of 1½ miles, into the recess of Lamlash Bay. It is a prominent landmark in the Firth of Clyde, as prominent almost as Ailsa Craig itself, and moreover of much the same shape. The island is extended in a N.N.W. to S.S.E. direction for 2 miles, and has an average width of half a mile. According to the Survey memoir and map of this district the Holy Isle consists of thick sills of felsite intruded into the third group (red sandstones and conglomerates) of the Lower Trias.[7] The latter occupies a narrow strip on the western and southern sides of the island, and is also intruded by a dolerite mass which forms a continuation of the Kingscross sill and by basalt dykes. The felsites, however, are probably later than the dolerites and basalts. According to the memoir they belong to the group of felsite sills, which seldom show free quartz and are usually non-porphyritic. These are believed to be later than

[1] Teall, Min. Mag., ix, 219–21, 1891.
[2] Harker, *Bala Volc. Ser. Carnarvon*, 1889, pp. 50–2.
[3] Q.J.G.S., l, 219, 1894.
[4] *Tertiary Igneous Rocks of Skye* (Mem. Geol. Surv.), 1904, p. 158.
[5] Geol. Mag., 1896, p. 376.
[6] *Petrology for Students*, 4th ed., 1908, p. 129; see fig. 33B, p. 128.
[7] *The Geology of North Arran, South Bute, and the Cumbraes* (Mem. Geol. Surv.), 1903, p. 70.

the contrasted group of quartz-porphyries, since they intrude the latter and are seldom pierced, as the quartz-porphyries are, by the ordinary basalt dykes.[1] In several places the 'felsite' of the Holy Isle forms great vertical cliffs showing a rude columnar jointing. On the western side of the island the igneous rock clearly rests on horizontal red sandstones and has a sill-like appearance.

The rock composing most of the island is a compact, hard, greyish, 'felsitic' material, which weathers deeply with a yellowish crust. On breaking open one of the large, loose, angular blocks which strew the slopes, a very regular concentric distribution of colour, due to gradations of alteration, is seen. The exterior yellow zone of decomposed material is often an inch thick, and, with regular gradations of colour, passes into fresher and fresher rock, and ultimately into a kernel of quite fresh rock. The latter is very compact, dark grey in colour, and shows minute, flashing cleavage-plates of sanidine. The rock frequently breaks into angular tabular fragments conditioned by a close horizontal jointing, and on steep slopes illustrates the formation of screes on a small scale to perfection.

Microscopically the rock consists of microporphyritic sanidine in a groundmass of smaller lathy crystals of the same mineral, with riebeckite and minute specks of iron-ore. The sanidine occurs in euhedral, rectangular, simply-twinned crystals, which are evenly and numerously scattered all over the field. The groundmass consists of subhedral laths of sanidine, closely packed together, with abundant riebeckite. The latter appears to occur in two forms, as in the Beinn Dearg granophyre. One set is in small independent prisms, parallel-sided in the prism zone, but with ragged irregular terminations; the other occurs in the well-known ophitic, mossy, or sponge-like masses. The latter are generally altered to an indeterminate yellow mineral, but the prismatic crystals are quite fresh and show the usual pleochroism from indigo-blue, through greenish-blue, to yellowish-green. Search was made for nepheline, but microscopic and staining methods failed to reveal any trace of this mineral.

The small laths of the groundmass show some approach to flow-orientation, but the numerous, short, stumpy, rectangular prisms of sanidine, dispersed in all directions throughout the rock, determine the texture as orthophyric. This, together with the intrusive mode of occurrence, renders the term riebeckite-orthophyre more appropriate than riebeckite-trachyte.

The rock differs from that of Ailsa Craig in being entirely devoid of quartz, which occurs both in the groundmass and as micro-phenocrysts in the latter rock. It is curious that these two islands, so similar in general appearance, should both be composed of riebeckite-bearing rock. If it were possible to examine the contacts of the Ailsa Craig mass, it is not improbable that it would be found to have geological relations similar to those of the riebeckite-orthophyre of the Holy Isle. The closest petrological affinities of the Holy Isle rock, however, are with the riebeckite-phonolite or

[1] *Geology of North Arran*, etc., p. 91.

orthophyre of the Eildon Hills, Melrose. The latter differs only in its somewhat coarser grain, and in the abundance and large size of its areas of riebeckite.

2. Crinanites of Whiting Bay and Dippin.—The crinanites are ophitic olivine-analcite-dolerites occurring as dykes in many parts of Argyllshire and the Western Isles. They are so called from Loch Crinan, which lies almost in the centre of their area of distribution.[1] They are closely associated with olivine-dolerites which differ from them only in the absence of analcite, and also with the remarkable monchiquites and camptonites which have recently been described from Colonsay and Mull. Complete descriptions of this suite of dykes have been given by Dr. J. S. Flett in recent Survey memoirs, and chemical analyses have been made in the Survey laboratory.[2]

These dykes have the north-west trend so common in the Tertiary suite of the Western Isles and the adjacent mainland. Their unusual petrological character, however, has rendered their connexion with Tertiary igneous activity of some dubiety. In the south of Mull a few undoubted Tertiary dykes of analcite-dolerite have been found, and Mr. Wright has found analcite-dolerites amongst the north-west dykes of the Beinn Dearg group in Skye.[3]

The crinanites show transitions to the camptonites in their type-locality, and also have many resemblances to the Carboniferous teschenites which are common in the Midland Valley of Scotland. Dr. Flett, however, enumerates four differences: they are finer in grain than the teschenites, have a perfect ophitic texture, hornblende and biotite are scarce, and they occur as thin, vertical, parallel dykes instead of sills.[4] One might add that in general they are much richer in olivine than the teschenites, but poorer in analcite and alkali-felspars. These mineralogical differences are clearly brought out in a comparison of the chemical analyses of the two rocks. The teschenites are much richer in alkalies and combined water, but considerably poorer in ferrous iron and magnesia.[5]

The present paper records the occurrence of a dyke of crinanite at Whiting Bay in the south-east of Arran, and also records that the great sill of Dippin, hitherto regarded as a teschenite, is much closer in its affinities to crinanite. The sills of Kingscross and of the Clauchland Hills are also to be regarded as crinanites. All these rocks intrude the Triassic sediments, and are most probably of Tertiary age. The Arran occurrences thus furnish one more link in the chain of evidence which connects the crinanites and the associated monchiquites and camptonites of the type-locality of Argyllshire with Tertiary igneous activity.

[1] *Summ. Prog. Geol. Surv. for 1909*, 1910, p. 52.

[2] *The Geology of Knapdale, Jura, and North Kintyre*, 1911, pp. 116–18; *The Geology of Colonsay and Oronsay, with Part of the Ross of Mull* (Mem. Geol. Surv.), 1911, pp. 41–6.

[3] *The Geology of Colonsay and Oronsay*, 1911, p. 41.

[4] *The Geology of Knapdale, Jura, and North Kintyre*, 1911, p. 117.

[5] For analyses of teschenites see *The Geology of the Neighbourhood of Edinburgh* (Mem. Geol. Surv.), 1910, p. 299.

Petrography.—On the shore of Whiting Bay and at Kingscross Point are numerous rounded pebbles and boulders of a fresh doleritic rock which is rendered prominent by a distinct spotting of rounded lighter areas on a darker ground. Ultimately this rock was traced to a thick dyke penetrating the Triassic sandstones on the shore of Whiting Bay, a little to the north of the School.

In thin section the rock is seen to consist of an ophitic plexus of plagioclase and augite, in which the former is largely predominant. Fresh olivine is very abundant, and a skeletal or platy ilmenite only less so. Analcite or a fibrous radiating zeolite fills many of the polygonal interspaces between the felspar laths. The plagioclase is euhedral and zonal, the composition ranging from acid labradorite (Ab_1An_1) in the interior to oligoclase (Ab_4An_1) in a thin marginal zone. As usual, the undulose extinction due to zoning is very prominent in untwinned sections cut parallel to the clinopinacoid. The augite is a deeply-coloured purplish variety, with a pleochroism ranging from deep purplish-brown to a pale sepia, and is probably rich in titanium oxide and alkalies. It is very subordinate in quantity to the plagioclase, and is cut up by the latter into thin strips and small triangular or polygonal patches. The abundant olivine is very fresh, or at most has suffered only incipient serpentinization, and occurs in small, more or less rounded, subhedral granules, which are frequently enclosed along with ilmenite in the plates of augite. Turbid but still isotropic analcite fills up many of the straight-sided interspaces between the felspars. In some cases, however, the spaces are filled with a low-polarizing, radial zeolite, whose optical characters agree with those of scolecite. The ilmenite is mostly skeletal, but sometimes occurs in long thin plates or rods, which are enclosed in and earlier than the titanaugite, but frequently mould the terminations of felspar laths. Occasionally small scraps of red biotite are associated with the iron-ore. The spotting visible in the hand specimen is due to a comparative scarcity of the ferromagnesian minerals in certain areas, and is only recognizable with difficulty in thin section. From this description it will be evident that this rock is identical with crinanite. I have been able to confirm the identification by comparison with slides of typical crinanite from Argyllshire kindly lent by the Geological Survey.

The great sill of Dippin which has been described by Corstorphine as olivine-analcime-diabase,[1] and by Harker as teschenite,[2] appears to me to be more nearly related to crinanite. It agrees with the latter in the perfect ophitic relations between augite and plagioclase, and in the abundance of fresh olivine, both of which characters are very unusual in the teschenites. In many specimens (e.g. from the north end of the Dippin cliff) the interstitial analcite is not at all prominent. Only in some outcrops in Glen Ashdale does the analcite become as abundant as in the teschenites. The mass of the Dippin rock, however, is much coarser in grain than is usual with the typical crinanites, but this, of course, is conditioned by its mode of occurrence

[1] *Tscherm. Min. Petr. Mitth.*, xiv, 463–5, 1895.

[2] *The Geology of North Arran, South Bute, and the Cumbraes* (Mem. Geol. Surv.), 1903, pp. 112–14.

in thick sills. Near the contacts the Dippin rock becomes identical with crinanite even in the matter of grain-size.

The sill of Kingscross Point must also be correlated with the Dippin sill and with the crinanites. It differs from the Dippin rock in carrying a much smaller quantity of interstitial analcite and zeolites and in a finer grain-size. The felspars are approximately equal to the titanaugites in bulk, but the individual crystals are much smaller. The ophitic plates of titanaugite are pseudo-porphyritic in a groundmass composed of closely packed laths of plagioclase. The Kingscross sill has suffered a curious veining by a tachylytic basalt, and has also developed pegmatitic variation-facies in which analcite and other zeolites are very prominent.

From Allport's description it is probable that the great sill which caps the Clauchland Hills is also a crinanite. He says: "A typical specimen from Dun Fion contains crystals of plagioclase beautifully striated, augite and olivine in a remarkably fresh condition, magnetite, a few plates of brown mica, a little apatite, and a clear amorphous glass in the interstices of the constituents."[1] The "clear amorphous glass" is almost certainly analcite.

All the rocks described above are unquestionably Tertiary in age. Very similar rocks, however, are to be found amongst the alkalic Late Carboniferous or Permian eruptives of Ayrshire.[2] Most of the rocks of this sub-province which are to be regarded as related to crinanite are intrusive in the Permian sandstones and underlying lavas of the Mauchline basin, and are associated with analcite-syenite. A good crinanite from an intrusion at New Gilston, Fifeshire, has recently been brought to my notice by Miss A. T. Neilson, of the Hunterian Museum, University of Glasgow.

REVIEWS.

I.—Geological Survey Memoir.

The Geology of the Lizard and Meneage. By Dr. J. S. Flett, M.A., and J. B. Hill, R.N. 8vo; pp. viii, 280, with 15 plates and 10 text-illustrations. London: printed for His Majesty's Stationery Office, 1912. Price 5*s*.

MENEAGE, as we are told in the preface to this memoir, is an old Cornish name for the Lizard promontory, south of the Helford River; so that the name applies to the whole of the Lizard area, but strictly speaking not to the northern margin in the Geological Survey map, which includes Rosemullion Head on the east and Breage on the west. The colour-printed map (Sheet 359) shows clearly the line of demarcation between the igneous and metamorphic Lizard Series and the mainly sedimentary series, which in old days was known generally as 'killas'. This forms the northern portion of the area, together with some intrusive and interbedded igneous rocks, including a fringe of granite at Constantine and a small tract at Breage. The two great rock-series appear to be

[1] Q.J.G.S. xxx, 563, 1874.
[2] Tyrrell, Geol. Mag. (V), IX, 124, 1912.

separated by a fault or thrust-plane, heading to the south and south-east, and carrying well-marked breccia. The disturbance is well shown near Polurrian Cove on the west and near Porthallow Cove on the east, but it cannot be definitely traced throughout the intermediate ground.

The southern area has been mapped and described by Dr. Flett, the northern by Mr. Hill. The entire region is a somewhat irregular plateau, averaging about 280 feet in elevation, but rising on the serpentine of Goonhilly Down to 370 feet, and on the hornblende schist of Roskruge Beacon, west of Porthallow, to 378 feet. This plateau, eroded to a great extent probably in Miocene and early Pliocene epochs, was further planed down in later Pliocene times, when the area was submerged to the extent of about 420 feet. Relics of gravels regarded as of Pliocene age (but not fossiliferous) occur on the gabbro of Crousa Common north of Coverack.

The coastline in general is rugged and rocky, and often difficult of access, but characterized by numerous highly picturesque coves, while the broad tidal waters of the Helford River and the Loe valley south of Helston are bordered by wooded slopes of great beauty. The region in general is described as essentially an agricultural and not a mining country, and in this respect it compares with the metamorphic area of Salcombe in South Devon, which is included in the fertile district of the South Hams. In the Lizard the least cultivated portions are on the serpentine, which yields a thin clayey soil, liable to be waterlogged; and the land is comparatively barren and dreary.

A full, and in all respects excellent, account of the previous literature relating to the Lizard Series is given by Dr. Flett, and it is interesting to read of the gradual progress of knowledge and of the diverse views concerning the origin and relations of the rocks in this complex area. To the elucidation of the problems Professor Bonney, Dr. Teall, Mr. Howard Fox, Mr. Harford J. Lowe, also the late General McMahon and Alexander Somervail, have been the principal contributors. It has remained for Dr. Flett to examine in detail the entire area and bring the experience gained by seeing the whole of the evidence to the interpretation of the mineral changes in the rocks, their sequence, and structural features; and it may be affirmed that as complete a story as possible has been unfolded by the masterly way in which this petrographical area has been investigated. The one point on which we fail to find definite expression of opinion is that of the geological age of the Lizard rocks, though it may be inferred that Professor Bonney's reference of the mica schists to the Archæan is not contested by Dr. Flett, who regards the Old Lizard Head Series as "an important part of the Lizard schists".[1] Moreover, the intimate connexion of the series appears manifest when we read that "in 1893 Somervail advanced the hypothesis that all the principal rocks of the district, the hornblende schist, serpentine, gabbro, black dykes, and banded gneisses, were differentiated from one magma. As he had already arrived at a correct conception of the sequence of these rocks, he may be regarded

[1] See also Flett's account of "The Geology of the Lizard" (Proc. Geol. Assoc., xxiv, p. 118, 1913).

as the first to solve one of the most fundamental, and at the same time most obscure, problems of Lizard geology".

With regard to the vexed subject of fluxion banding and foliation, it is remarked that "in the plutonic and intrusive rocks of the Lizard there is a foliation intimately connected with the injection of the igneous magma, but it is clear also that earth-movements were going on at the same time. The most important fact to bear in mind is that the igneous rocks can be shown to have attained their present metamorphic state as soon as, or very shortly after, they had consolidated".

The following sequence, in descending order, is recognized by Dr. Flett:—

Granite and Granite Gneiss.
Kennack Gneisses (banded).
Dolerite and Epidiorite dykes.
Gabbro (with augen gabbro and gabbro schist).
Troctolite.
Serpentine (Bastite, Tremolite, and Dunite varieties).
Hornblende schists: Traboe schists.
Treleague Quartzite.
Man of War Gneisses.
Hornblende schists: Landewednack schists.

Old Lizard Head Series	Green schists.
	Granulites.
	Mica schists.

It is pointed out that sedimentary rocks are represented by the mica schists, granulites, and Treleague quartzite; and that the varieties of serpentine pass one into another, the dunite variety being the marginal facies, the tremolite serpentine adjoining it, and the bastite variety or lherzolite being the central rock.

In separate chapters full particulars are given of the subdivisions of the metamorphic rocks of the Lizard Series.

Turning now to the northern series of rocks, we find the sedimentary Mylor, Falmouth, and Portscatho Series of Mr. Hill, grouped as Ordovician (?), although as they presumably underlie the Veryan Series regarded as of Llandeilo or Arenig age, and "probably Arenig", the three former series may include rocks that are pre-Ordovician. Only the Veryan Series has yielded fossils, and with it are grouped the Radiolarian cherts of Mullion Island. Lower Devonian is recognized in the Manaccan Beds, which consist of slate, sandstone, and conglomerate, with fragments derived from the Portscatho and Veryan rocks. The sequence maintained by Mr. Hill has, however, been contested by Mr. Upfield Green and Mr. C. D. Sherborn, who, in their latest grouping, place the "Dartmouth, Falmouth, Ladock, Grampound, Manaccan, Mylor, Portscatho, and Veryan" Beds in the Lower Devonian (Gedinnian); and they apply the term Veryan to "beds containing lenticular inclusions yielding Ludlow, Wenlock, and Woolhope fossils", placing them beneath the Manaccan Beds and above the Ordovician quartzites of Gorran.[1] There does not appear to be any justification for this application of the term Veryan, as it strictly belongs to the strata (thin limestones, Radiolarian cherts, slates, quartzites, and pillow-lavas) grouped by Mr. Hill as Ordovician.

[1] See GEOL. MAG. for 1912, p. 560.

The important discoveries of Silurian (Ludlow) fossils made by Mr. Green and Mr. Sherborn in "Black slates with limestone lenticles" at Fletching's Cove near Porthalla (Porthallow on map), and in the "Slates with inclusions" at Nare Cove, south of Nare Head, do not prove that the inclusions and lenticles are of a conglomeratic character and of Devonian age. In such a region of faulting and thrusting and probable infolding, it would seem more likely that the inclusions have been brought about by disturbance. The fact observed by Mr. Hill that the Manaccan conglomerate contains fragments of the Portscatho rocks, etc., does not appear to have been taken into consideration by Mr. Green and Mr. Sherborn, and this evidence strongly favours Mr. Hill's view that the Manaccan conglomerate forms the local base of the Devonian. It is to be hoped that these three geologists may be able in due course to harmonize their views. Materials for the definite determination of some of the problems are still wanting. It has been pointed out that the absence of any fragments of the Lizard Series in the Ordovician and Devonian rocks of the area is remarkable, and cannot be satisfactorily explained; and there are features that have led Mr. Hill to see evidence of a transitional passage from the Veryan group into the Lizard Series. The facts for and against this hypothesis are fully discussed in the memoir, wherein it is stated "that this difficult problem is not yet by any means settled".[1]

In thus referring to the chief controverted subjects, we have no space in which to enlarge on the accessions to knowledge in reference to the various igneous rocks and to metamorphism. It should be mentioned, however, that apart from the Lizard Series there are pillow-lavas (spilites), granite, elvans, and mica-traps in the northern area, and these are duly described. Some account is given of the possible derivation of the Gunwalloe beach-shingle from an old Eocene deposit, and then follow descriptions of the Pliocene gravels, raised beaches and head, submerged forests, and coast erosion. An interesting and instructive account is given of the soils and agriculture, followed by notes on the water supply, building materials, serpentine industry, and mining, to which last subject Mr. D. A. MacAlister has contributed.

The plates include excellent views of scenery, rock-structures, and photomicrographs of rocks, and among them is one of a "Glacial Boulder on the Beach at Porthleven". This, known as the "Giant's Rock", is a block, about 50 tons in weight, of "microcline gneiss of a type unknown in Britain", and has evidently been derived from the raised beach.

II.—Primitive Brachiopods.

Cambrian Brachiopoda. By Charles D. Walcott. Monographs of the United States Geological Survey, vol. li, part i, pp. 1–872; part ii, pp. 1–363; plates i–civ. 4to. Washington, 1912.

THIS immense work is another example of the wonderful energy of American scientific investigators, and is a further proof of their very comprehensive grasp of their subjects. Not alone the students

[1] See also Hill, Proc. Geol. Assoc., xxiv, p. 153, 1913.

of Palæozoic rocks, but all palæontologists and all evolutionists owe to the gifted author, Dr. Walcott, their cordial thanks for a monograph dealing so fully with the Brachiopod fauna which existed in those far-off days when the earth was yet in her youth.

Looking at these two fine volumes, with their testimony to careful scientific work on every page—these two volumes published by the United States Geological Survey, well printed and magnificently illustrated—one is doubtful whom to envy most, the scientific investigator who has not only the ability and the patience but also the time to execute such a task, or the Government which so ably places his results before the world. For publication is a very important factor. There is nothing more stimulating to any worker than to know that his task when accomplished will be adequately printed; there is nothing which undermines the worker's energy more than a doubt whether his work may ever see the light, while the feeling that it may in the end be mutilated or very inadequately presented on the score of expense is almost as fatal. Scientific workers in other countries, then, might be forgiven if they exclaim to Dr. Walcott, or to his Government, "Almost thou persuadest us to become Americans!"

What, however, of the contents of these volumes? To criticize them in detail would be futile. Dr. Walcott has made a life study of the faunas of the Cambrian rocks, and his expert knowledge is of worldwide reputation, proved and attested by many previous communications. The present monograph on the Cambrian Brachiopods of the world has occupied the author for the last ten years: that it has been accomplished in that space of time is a tribute to the author's untiring perseverance.

"This monograph includes the description of 44 genera, 15 subgenera, 477 species, and 59 varieties of Cambrian Brachiopoda, and of 3 genera, 1 subgenus, 42 species, and 1 variety of Ordovician Brachiopoda. . . . In this paper the Brachiopoda are treated in three ways—historically, geologically, and zoologically. Historically the treatment comprises (1) a bibliography and (2) a table of synonymic reference. . . . Geologically the distribution of the Brachiopoda is considered under the following headings: (1) General geographic and stratigraphic distribution; (2) detailed geographic distribution; (3) detailed stratigraphic distribution; (4) habitat; and (5) fossil localities. Zoologically the discussion covers (1) the physical characters of the Brachiopoda; (2) their distribution; (3) their evolution; and (4) their classification. Lastly come the detailed descriptions of genera and species and the illustrative plates" (p. 11).

The number of species of Cambrian Brachiopoda is remarkable; it is an interesting picture of how much development and differentiation had been accomplished even in those early days. Tables of Detailed Geographic Distribution are given in pp. 114 et seqq., but one misses a comparative analytical table of numbers of species in different regions. North America supplies by far the largest number—the species are some hundreds; but as a remarkable contrast South America is credited with only five species. Next to North America

in point of numbers comes Europe with about a hundred species, but the British Islands can only boast about one-fifth of this total; the greatest number is provided by Scandinavia, including Finland. Asia yields about forty species and Australia six, but there can be little doubt that further exploration of these regions would increase the number.

This very elaborate monograph cannot fail to be of the utmost importance to the student of the Brachiopoda of the Palæozoic rocks. There is a bibliography extending to thirteen pages, and, what is always of the very greatest assistance to the worker, there is an exhaustive Table of Synonymic References—how exhaustive may be judged from the fact that it extends to about seventy pages; it is also testimony to the large amount of investigation, and the constant rearrangement in the light of further knowledge, which the Cambrian Brachiopods have received. That the present monograph exhibits the nomenclature in anything like a final form no one could pretend to hope, especially when it is considered how very obscure are some of these small fossils, and how difficult they are to interpret. But the energy which Dr. Walcott has brought to bear on the elucidation of his subject deserves our warmest thanks. America may well boast of the industrious, and, what is perhaps more important, of the very progressive investigators of Brachiopoda which she has produced, men who have given us what has almost seemed to be revolutionary work. James Hall and C. E. Beecher, Professor J. M. Clarke, Professor Schuchert, Dr. E. R. Cumings, and others form with the writer of the present monograph a band who have made our knowledge of fossil Brachiopoda, especially of the older formations, advance from comparative chaos to well-arranged order.

Considering the nature of the remains and the magnification so frequently required, the excellent plates are deserving of special commendation. Dr. Walcott says (p. 13): "the drawings have been prepared mainly by Miss Frances Wieser, of the United States Geological Survey. The plates are the evidence of her faithful work." They are; it is not only good work but a magnificent task. There are over a hundred plates, and the number of separate figures must run into several thousands, figures full of fine detail, all very carefully executed. Nothing more beautiful has been placed before the student of Cambrian Brachiopoda: perhaps if we said of any Brachiopoda it would not be incorrect.

There is a small matter connected with the plates—mainly an editorial matter—to which we would call attention. It is very desirable that all the explanation of each plate should appear in the one opening, opposite the plate. In view of the immense amount of literature, workers' time should be saved in every way, and reference to figures of a plate should be made as clear and easy as possible. But this cannot be where there is the too common fault of separating the explanation from its plate, or even, as in the work before us, carrying the explanation over to a leaf behind the plate. In many cases in the present work such carrying over has been quite needless, and all the explanation could have been placed on the facing page. In other cases the use of smaller type would have enabled the

required position to be achieved. In yet other cases where even that expedient would have failed, a skeleton explanation printed at the top of the facing page, to be followed by the detailed explanation, would have been of great assistance.

Anything which lessens chances of misquotation and facilitates reference to a work makes that work, in our opinion, the more valuable. And frequent reference to such a work as this is to be desired, for the monograph thoroughly deserves it. We congratulate Dr. Walcott on the completion of a magnificent task, most worthily executed. It is another monument to his great abilities.

III.—Catalogue des Invertébrés fossiles de l'Égypte représentés dans les Collections du Geological Museum au Caire. Par R. Fourtau. Terrains tertiaires. 1ère partie: Échinides Éocènes. 4to; pp. 1–93, pls. i–vi. Le Caire. Gouvernement égyptien. Administration des Arpentages. 1913.

DURING the Cretaceous and Eocene periods the Echinoid fauna of the Mediterranean region seems to have been one of the richest known from any part of the world. In the case of the former period the wealth of species and individuals may probably be ascribed to the littoral conditions then prevalent in Northern Africa, where, perhaps in a tropical climate, shore-life must have been uniformly prolific. It might be expected that the relatively pelagic conditions which came in with the Tertiary epoch would have resulted in a reduction in numbers and variety; and, indeed, it may yet be a question whether the list of 130 species recorded from the Egyptian Eocene alone may not in some measure owe its length to excessive zeal in the separation of 'species'. This question seems the more appropriate when it is found that the genus *Schizaster* is credited with eighteen species and *Echinolampas* with nineteen!

In the study of the fossil Echinoids of the eastern part of the Mediterranean the mantle of de Loriol has fallen upon M. R. Fourtau, and he proves himself a worthy successor in the task of analysing the, as yet, fragmentary knowledge of the fauna. The present catalogue supplies a valuable résumé of past work on Egyptian Eocene Echinoids, and adds not a few new forms to the list.

Although the main work is necessarily purely systematic, the author gives an interesting 'apologia' in his Introduction. The methods of systematists often seem to date from the earlier half of last century, when, in the absence of any definite creed of evolution, the slightest differences between two specimens must needs lead to their specific separation. Although M. Fourtau adopts these methods in no small degree, he gives at the outset a confession of faith in the principles of the "Enchaînements du monde animal". He anticipates that, with fuller knowledge, it will be possible to unite many of the 'species' described in his catalogue into genetic series, but he regards all such attempts at present as being prématuré. He differentiates very properly between the zoological and stratigraphical conceptions of species, and reluctantly restricts his palæontology to its geological aspect.

For the purposes of a catalogue such a course is inevitable. But M. Fourtau suggests that in no other place would any but systematic work upon Egyptian fossil Echinoids be appropriate or even feasible. Surely 130 species from one formation represent sufficient material for philosophical consideration! Any phylogenetic grouping, however tentative and even inaccurate, would be more illuminating than a purely alphabetical arrangement of species. May we express the hope that M. Fourtau, with his unique opportunities and peculiar knowledge, will at some future time yield to his temptation to discuss rather than describe his specimens.

In the catalogue under consideration there seem to be more than the average number of misprints and other small inaccuracies. Misprints in dates are always dangerous, and on p. 83, under the heading of *Echinolampas ovalis*, there occurs a flagrant case. Would it not be a safeguard if new species were indicated as such in words, and not merely ascribed to the author with a date? In the present work new forms appear, ascribed to R. Fourtau under the varying dates of 1912, 1913, and even 1914! In one case (*Conoclypeus delanouei*, var. *macropygà*) the legend to the plate includes the words 'nov. var.', whereas in the text it is found that the variety was described in 1908! Surely the removal of such fruitful sources of confusion to later systematists is worth a little care in the proof-reading. A discrepancy in the title of the work, as engraved on the plates and as printed on the cover, is a further illustration of the unnecessary trouble that may be caused to future bibliographers.

In spite of the above criticisms of detail, the catalogue as a whole must be regarded as an invaluable contribution to our knowledge of Eocene Echinoids, and its publication would, of itself alone, assure M. Fourtau a high place among systematic Echinologists.

H. L. H.

IV.—Structure and Affinities of *Sutcliffia*.

A PAPER in the *Annals of Botany*,[1] by Dr. Ethel de Fraine, concerns a fragment of a petrified stem which was obtained from the colliery at Dearnley, near Littleborough. The specimen is of Lower Coal-measure age, and obtained from a nodule in the roof of the workings, probably from the same seam as the stem of *Sutcliffia insignis*, described by Dr. Scott (Trans. Linn. Soc. London, ser. II, vol. vii, pt. iv). The specimen was of large size, 9·5 by 3·5 cm. being the maximum transverse dimensions, while the total length of the fragment was about 25 cm. The structure presents considerable complexity, and consequently a model of the vascular tissues was constructed, in order to elucidate the behaviour of the strands. The main vascular axis consists of a solid central strand of wood (aprotostele), surrounded by leaf-traces of varying size (the 'meristeles'); a network of extra-fascicular bands of wood and bast encloses the stele and 'meresteles', while a zone of secondary cortex forms the limit of the specimen. The leaf-traces ('meristeles') pass out from the protostele without appreciable disturbance of its tissues, and are precisely similar to it; they divide up irregularly into smaller bundles, and are ultimately entirely used up

[1] Vol. xxvi, No. civ.

in the production of the small concentric foliar traces. Occasionally accessory concentric bundles are present, recalling the similar strands which occur in the cortex of *Cycas*. The vascular strands of all orders, except the ultimate foliar traces, are surrounded by a broad zone of secondary wood. On account of the general structure of the vascular system, the origin and behaviour of the 'meristeles', the leaf-trace bundles, and the close agreement in histological details (such, for example, as the pitting on the tracheidal walls), the stem is included in the genus *Sutcliffia* of the family Medulloseæ. It is provisionally attributed to *Sutcliffia insignis*, Scott, for the additional features which are characteristic of the specimen are such as would be expected to occur in an older stem: such features are the occurrence of secondary wood, the extra-fascicular strands, the secondary cortex, and the absence of leaf-bases.

The specimen is of some importance on account of the additional light which it throws on the affinities of the extinct family of the Medulloseæ. The great possibility of the origin of this group from a fern-like ancestry has been fully considered elsewhere, and many investigators have regarded it as the source of origin of the Cycadaceæ. The discovery of the present stem adds considerable weight to this view, for in many respects the structure is of a distinctly Cycadean type. It is suggested that by modification of the protostele and elaboration of the extra-fascicular zones of some such genus as *Sutcliffia*, the Cycadaceæ were evolved; while, on the other hand, increasing complexity in the number and arrangement of the steles may possibly have led through such a type as the English *Medullosa anglica* to the complex Permian Medulloseæ.

V.—Fossilium Catalogus. I. Animalia. Editus a F. Frech. Pars 1: F. Frech, Ammoneæ Devonicæ (Clymeniidæ. Aphyllitidæ, Gephyroceratidæ, Cheiloceratidæ). 4to; pp. 42. Berlin: Junk, 1913. Price 4 marks.

THIS seems to be just one of those works whose usefulness fails because the compiler refuses to adhere to a strictly alphabetical arrangement. So splendid an example of what an Index Palæontologicus should be was bequeathed to science by H. G. Bronn that it is difficult to comprehend the mind of those who spend their time on a systematic arrangement which in nearly every case can only be of service to the narrow specialist, and little indeed to him, for he already knows his subject. Further, why limit the references to Devonian forms? There is already much grumbling among those who have to consult the three or four indexes extant for generic names and a request that they may all be thrown into one, but in this proposed work we are threatened with a separate index not merely to each group but to each geological horizon of the families of the group.

In the work itself we consider that a date should be attached to *each* entry. We note the twenty-nine titles quoted do not represent the complete literature; we do not understand on what authority the name *Agoniatites*, Meek, is rejected for *Aphyllites*, Mojs.; and we hope "Mopisovus" on p. 25 will be intelligible to the uninitiated.

If our German friends would organize a staff and get another 'Bronn' ready for the next generation they would be doing a real service to Palæontology, but we honestly think that work published in parts in this way is of little or no service to the real worker, especially when it is arranged in systematic and not alphabetical order. It is never wise to introduce into a reference book any personal idiosynerasies.

VI.—The Earth: its Shape, Size, Weight, and Spin. By J. H. Poynting, Sc.D., F.R.S. 8vo; pp. 141, with 49 text-figures. Cambridge: at the University Press, 1913. Price 1*s.* net.

DIFFERENT branches of geology have been dealt with in previous volumes of this enterprising series, and Professor Poynting's little book is concerned with the earth from a physical aspect. There are only three chapters, and their simple-sounding titles are: "The Shape and Size of the Earth," "Weighing the Earth," and "The Earth as a Clock." In telling the story of the growth of the idea of a round earth, the author would take us to the top of a hill on a clear day to look over a stretch of lowlands, where we might with the ancients conclude there was nothing to suggest that the earth is not flat. In our first chapter we are told how a different conception of the earth's form came into being, and how Columbus proposed to reach India by sailing to the west. A few simple figures and some easy calculations are given in support of the modern view, and these are followed by a description of the method of measuring distances on the earth's surface. The base-line method of measuring is illustrated also by an account of the finding of the distance of the nearer stars.

In beginning his second chapter the author illustrates clearly the relationship between the weight and mass of the earth. We then read of the earth-weighing experiments—the early ones of Newton, Bouguer, Maskelyne, and Cavendish, and the later and more delicate one of Professor Boys. When considered as a clock, our planet is regarded, of course, as whirling round the sun, and we see how the spin of the cyclones is connected with this movement. The principle of Foucault's pendulum is also dealt with. But by far the most interesting topic is that of the tides, which are treated in connexion with Sir George Darwin's discoveries. It is shown that the tides are gradually reducing the earth's spin, that the action of the moon on them is gradually lengthening the day, and the reaction of them on the moon is lengthening the month. The same reckoning points to the probability of the moon and the earth forming the same body in the past, and the likelihood of the moon's ending her journey by reunion with the parent globe in the far-distant future.

VII.—Effects of Pressure and Temperature on Rock-formation.

GEOLOGICAL speculations on matters connected with the formation of rocks have often been founded on misunderstood or misinterpreted experiments. Mr. John Johnston and Mr. L. H. Adams, in a paper on the effect of high pressures on the physical and chemical behaviour of solids, published in the number of the *American Journal*

of Science for March, 1913, have done good service by collecting and critically discussing the available data. They point out that a non-uniform pressure, i.e. one involving a shear, is an incomparably more effective agency than a uniform pressure, which is not so important as a high temperature.

VIII.—On the occurrence of Nepheline in Phonolite Dykes at Omeo. By Professor E. W. Skeats. Section C: pp. 126–31, with one plate. Australasian Association for the Advancement of Science, 1912.

THIS paper gives a list of previous records of felspathoids in Victoria, and shows that most of these have been due to incorrect determinations. The author corrects his previous record of nosean and melilite in the alkali rocks of Mt. Macedon.

A brief sketch of the geology of Omeo, Eastern Gippsland, is given. Granites and quartz-diorites are intrusive into pre-Ordovician or pre-Cambrian schists, and there is a group of anorthoclase-trachytes and solvsbergites, which are younger than the plutonic rocks. Another group of dykes occurs at Omeo, and the phonolite dykes here described are the youngest in this area.

The rocks are described in detail, and the percentages of alkalies in one rock have been determined. The mineral composition is: soda-orthoclase 46, nepheline 28, and ægirine 25 per cent. A mineral occurring interstitially between the felspars is referred provisionally to cancrinite.

IX.—Canada.

Geological Survey of Canada.

(A) In Memoir No. 17E (1912) is an account of the "Geology and Economic Resources of the Larder Lake District, Ont.", by Mr. M. E. Wilson. The formations shown on the map are Keewatin (greenstone and various schists, slate, dolomite, quartz-porphyry, and rhyolite), Pontiac schist, Laurentian (granite, gneiss, etc.), Huronian (conglomerate and greywacke), Post Lower Huronian (diabase, etc.), and Pleistocene and Recent deposits. The mineral products include gold, silver-lead, copper, cobalt, nickel, molybdenite, and iron. The report contains interesting views of scenery and rock-structures.

(B) Memoir No. 35 (1912) gives the results of a "Reconnaissance along the National Transcontinental Railway in Southern Quebec", by Mr. J. A. Dresser. The rocks described include Cambrian, Ordovician, Devonian (igneous), and Drift. The district has been glaciated from the N.N.W., and the rock surface is generally, and in places heavily, covered by soil. Stratified Drift deposits of clay, sand, and loam occur in the lowlands and in some of the upland valleys. The mineral prospects are not of great promise. Small quantities of asbestos, chromite, chalcopyrite, and bog iron-ore occur; there is slate of good quality, also quartzite, and peat-bogs. Much of the district is suitable for farming, and part for lumbering. Among the illustrations there is a striking view of the St. Lawrence lowland.

(C) Department of Mines, Canada: Mines Branch, 1912.

Pyrites in Canada. By A. W. G. Wilson. pp. xi + 202, with 27 plates, 26 tables, 29 figures in the text, and 1 map.

This report, while outlining the pyrites resources of Canada, has for its object the promotion of a further development of these resources. It is pointed out that, if a steady supply of a uniform grade of ore were assured, more than four times the present production in Canada of this ore would find a ready market. This market might be still further increased on account of the rapid expansion of the sulphide pulp industry in Canada.

The book gives a short account of the chemical and physical properties of the chief sulphur ores, and notes on the mining and marketing of pyrites. The statistics of the production of pyrites are given in fifteen tables.

The occurrence of pyrites in Canada is treated at length, some forty prospects being described. This chapter is illustrated by an admirable series of photographs and by a map showing the positions of the pyrites deposits in Eastern Canada. The same chapter contains descriptions of the pyrrhotite at Sudbury, Ontario, and of the famous pyrites deposits of Huelva, Spain, and of Norway and Japan.

The remaining chapters deal with the roasting of pyrites, the manufacture of sulphuric acid, and the importance of pyrites to the paper-manufacturing industry. Appendices give a list of firms interested in Canadian pyrites, types of furnaces used for burning sulphur, a discussion of the use of pyrrhotite as a sulphur ore, and of the contact process for the manufacture of sulphuric acid.

The book is most profusely illustrated. It contains a fund of information of a highly practical nature which must prove invaluable to those actively engaged in the production of pyrites, while its less technical matter cannot but appeal to those interested in the scientific aspects of pyrites deposits.

(D) Mineral Production, Canada, 1911–12.

(1) A general summary of the mineral production of Canada during 1911.
(2) Preliminary report on the mineral production of Canada during 1912. By J. McLeish.

The decrease in mineral production of 1911, as compared with 1910, is attributed largely to the strike of coal-miners in Alberta and in the Crowsnest district of British Columbia. The preliminary report for 1912 shows an increased production for every important mineral mined with the exception of petroleum. The working of the nickel-copper ores of the Sudbury district of Ontario in 1912 shows a greatly increased output. Small shipments of nickel ore were also made in 1912 from the Alexo Mine at Kelso in the Nipissing district.

(E) Geological Survey, British Columbia.

Map 62A (to accompany Memoir 34). Nelson and vicinity, West Kootenay, British Columbia.

A geological and topographical map of an area of about 120 square miles, on the scale of 1 mile to the inch, with contours at intervals

of 250 feet. It is based on the map published in 1904, and gives the relations of the Nelson batholith (granites, monzonites, and quartz-diorites) and its accompanying dykes to the rocks of the Rossland and Pend d'Oreille groups (? Carboniferous).

X.—Professor Doelter's Mineralogy.

THE first part of a second volume of Professor Doelter's great work (*Handbuch der Mineralchemie*, edited by Hofrat Professor Dr. C. Doelter; vol. ii, pt. i, pp. 160; Dresden and Leipzig, Theodor Steinkopff, 1912; price 6·50 marks net), which deals with silica and the silicates, comes fully up to its predecessors in point of view of interest and importance. It opens with a resumé by Professor Becke of the physical characters of the silicates. He compares the refraction of many species with the corresponding value calculated from Gladstone and Dale's well-known law; the agreement is often very close, but discrepancies are met with which call for further investigation. The general theory of the optical characters of isomorphous mixtures is considered, with special reference to the plagioclase felspars. A lucid and thorough account of the paragenesis of the silica minerals comes from the pen of Professor J. Koenigsberger. Professor Doelter himself writes on the vexed question of the constitution of the silicates, and discusses the various theories that have been put forward. He also describes very fully the physical characters of quartz, chalcedony, and opal, the information given being exhaustive and well up-to-date.

XI.—United States Geological Survey.

WE have received Water-supply Papers Nos. 281, 283, and 301, dealing with the Surface Water Supply of the United States, including the North Atlantic Coast and Ohio River Basin; also No. 299, part ii, dealing with stream measurements in San Joaquin River Basin, California. Illustrations are given of the apparatus used in gauging the flow of streams. In No. 299 there are views showing the measurements made by the engineers of the Geological Survey by means of a current meter, which is operated from a bridge, a car suspended on a cable, a boat, and by wading.

The Thirty-third Annual Report of the Director (Mr. George Otis Smith) for the year ended June 30, 1912, contains a useful map showing areas of the United States covered by geologic surveys. There are some interesting remarks on the work of the Committee on Geological Names, their duty being to consider all geologic names of formations suggested by members of the Survey, prior to publication in both official and unofficial works. During the past fiscal year the Committee "considered 143 manuscripts, comprising a total of 21,614 pages and about 5,000 geologic names". Various card-catalogues bearing on nomenclature are kept up for the Committee, whose useful labours might well be followed in other countries.

Bulletin No. 471 (1912) consists of "Contributions to Economic Geology (short papers and preliminary reports), Part II, Mineral Fuels". The subjects dealt with are petroleum and natural gas, coal and lignite; including gas in Alabama, petroleum and gas in Kentucky and Utah, petroleum in California and Wyoming, coal in North Carolina, Colorado, North Mexico, Utah, and Wyoming, lignite and coal in Montana, and lignite in North Dakota. These short papers and reports occupy, with index, etc., 663 pages, and they are accompanied by 62 plates (maps and sections) and 15 text-illustrations. They include topographic and geologic descriptions, records of borings, analyses, etc.

Taking, for example, the report on the "Geology of the San Juan Oil Field, Utah", by Mr. E. G. Woodruff, we learn that the oil-field is situated in the valley of the San Juan River in south-eastern Utah, that the area is part of the Colorado Plateau, consisting of much irregular and uneven ground, of which about 80 per cent is destitute of vegetation, and subject to erosion by the local and occasional, but copious, rains. There are two canyons with precipitous walls, about 1,400 feet deep, and possessing grand scenic beauty. More than 5,000 feet of strata ranging from Carboniferous to Jurassic are exposed in the field, and it is in the older strata, the Goodridge formation of the Pennsylvanian system, that the oil occurs. The oil is generally found in sand or sandstone, but small quantities occur in limestone. The Goodridge Sand, 26 feet thick in places, is one of the most productive beds. Oil springs issue from different strata near the level of the San Juan River, the highest seeps in geological position being those from the Goodridge Sand, the lowest being in stratigraphic distance 1,450 feet below. The deepest well is 1,425 feet, but in some situations oil occurs at about 150 feet from the surface. It is noted that all the prolific wells are situated in synclinal strata, the area being "moderately complicated by north–south folds".

Bulletin No. 501 (1912) is on "The Bonnifield Region, Alaska", by Mr. S. R. Capps. The region contains productive auriferous placers and extensive lignite deposits; there are also possibilities of lode-mining. The report is well illustrated by photographic views and maps.

XII.—Cotteswold Naturalists' Field Club.

PART I of vol. xviii of the Proceedings of this Club (1913) contains the address of the President, the Rev. Walter Butt, who dealt with some problems connected with Prehistoric Man, and concluded that the earliest safe evidence of man's existence in the British Islands was in the Mousterian stage. Reports of various excursions contain much of geological interest, especially in reference to Droitwich, Cleeve Hill, Thornbury and Aust, Painswick and Kimsbury Castle, Bath and Box (the report on which contains a plan of the Box quarries). A more distant excursion was made to Bridport (outside the bounds of the Club), and the report is accompanied by some excellent photographic views of cliff scenery. The original articles include a paper, with one plate, on "Some

Inferior Oolite Brachiopoda", by Messrs. L. Richardson and C. Upton; an account of "A Swallow-hole in the Inferior Oolite near Cheltenham", by Mr. Richardson; notes on "The Distribution of *Calluna* on the Cotteswolds", by Mr. H. H. Knight, who describes the relations of the heather to the soils and substrata; notes by Mr. Upton "On the abundant occurrence of *Involutina liassica* (Jones) in the Lower Lias at Gloucester"—here we miss a reference to the paper on this subject by H. B. Brady (Geol. Mag., 1864, p. 193); a paper, with one plate, "On the Stratigraphical and Geological Distribution of the Inferior Oolite Echinoids of the West of England (Supplement," by Messrs. Richardson and E. T. Paris; and a description of some "Well-Sinkings on Lansdown, Bath", by the Rev. H. H. Winwood, who refers to the attenuation of the Great Oolite, as indicated by the presence of Forest Marble. Particulars of that formation would be of interest, as it is not shown on the Geological Survey Map. Mr. Roland Austin has compiled a useful Index to the Proceedings of the Club (1846–1912). This replaces Mr. Richardson's Index of 1904.

XIII.—Lavorazione Rationale delle Solfare Virdilio e Mintinella. Monografia Technico-Economica. (A technical and economic Report upon the Sulphur-mines of Virdilio and Mintinella in Sicily: by Emmanuele Cimono, Engineer.) 4to; pp. 152, with 2 coloured plates. Palermo: Libreria Internazionale A. Reber, 1912.

ALONGSIDE the road between Naro and Campobello di Licata (Sicily) are the rich sulphur-mines of Virdilio and Mintinella, which form the subject of the elaborate and detailed monograph now before us. The object of this work is to present a rational scheme for the working of the sulphur, and the author hopes that it will be of permanent value, both scientific and economical. In configuration the sulphur-bearing basin has the shape of a wide horseshoe. The first part of this work is devoted to descriptive geological notes, in which the succession of the beds and mode of occurrence of the sulphur are described. The resemblance between the beds of Virdilio and Mintinella and those of other Sicilian localities is also discussed.

Engineering reports connected with the difficulties encountered in working the deposits are contained in the second part, in which also are incorporated the opinions of various authorities on the causes that conduce to vibration and rock-fracture, and suggestions as to precautions that might be taken against catastrophes resulting therefrom. Two schemes for working the mines are considered in detail: one for carrying on operations above ground, and another for underground working. The relative cost of either is discussed, and full calculations as to the amount of overlying material, of transport, excavation, banking, etc., have been included. Statistical tables and full details connected with the exploitation of the sulphur are contained in the last three parts of this monograph, which is illustrated by two good coloured plates of sections and plans.

XIV.—The Resources of Tennessee. By A. H. Purdue and W. A. Nelson. Vol. iii, No. 2, pp. 62–116, April, 1913.

IN this number A. H. Purdue contributes two short articles. One outlines the principles of water-supply for cities and towns, and is illustrated by a section showing the water-bearing strata at Etowah. The other points out the grave need for geological investigation of the foundations of large engineering structures.

C. H. Gordon has written an account of the principal types of iron-ore deposits and their origin, with special reference to Tennessee. The deposits of limonite of East Tennessee are shown to be due to the weathering, probably in Tertiary times, of ferruginous limestones of Ordovician age. The hæmatite deposits are of two types: residual deposits, due to the leaching out by surface waters of calcium carbonate in ferruginous limestones; deposits of the Clinton type, in which the hæmatite occurs as beds of original deposition which have since undergone secondary enrichment. This paper contains four figures and numerous analyses.

The discovery of Mastodon remains in a quarry near Nashville is recorded. The remains consisted of teeth and bones, and were found at a depth of 15 feet in a clay-filled solution channel in the Carters Creek Limestone.

XV.—Brief Notices.

1. Institution of Mining and Metallurgy.—We have received the Presidential Address delivered on March 13, by Mr. Bedford McNeill, F.G.S., before this Institution. He discusses the relations between mining and capital, the extension of mining, and makes especial reference to the relative and average annual production of gold and silver at various periods from 1493 to 1911. He also calls attention to the meeting of the International Congress of Mining, Metallurgy, Applied Mechanics, and Practical Geology to be held in London in 1915. The address is accompanied by an admirable portrait of the President.

2. Sinai: Gebel Hammân Farûn.—Mr. G. W. Murray has an interesting note on the structure of this hill in the *Cairo Scientific Journal*, vol. vii, pp. 21–4, February, 1913. The sea-face of Gebel Hammân Farûn shows 45 metres of bedded basalt resting unconformably on variegated shales yielding many fossils, including *Hemiaster*. The basalt is overlain apparently conformably by 15 metres of Oyster limestones, among which *Ostrea vesicularis* is conspicuous. The evidence points to a contemporaneous flow in Santonian times. The hill is faulted down at its north-west end, and the basalts are not seen therefore at the point of previous interest, where the hot springs gush out amongst the beach shingles for some 400 metres.

3. Californian Tertiary Sharks.—Messrs. Jordan and Beal, having received a large collection of shark's teeth from the Kern River, near Oil City, have been enabled to add several species to the fossil sharks of California. When describing these in the Bulletin of the University of California, 1913, they have taken the opportunity

of giving a table of the geological range of Western American sharks from Triassic to Pleistocene.

4. Californian Eocene Mollusca.—A number of new forms of Eocene Mollusca have been described from the Marysville Buttes by R. E. Dickerson in the Bulletin of the University of California, 1913. The beds were deposited on a coarse-grained andesitic valley floor, overlain by gravels and sands (Ione Beds), which in their turn were capped with andesitic mud-flows, subsequently firmly cemented. The fauna is considered to have accumulated in 100 fathoms under tropical or sub-tropical conditions.

5. Foraminifera of Southern California.—The Bulletin 513 of the Department of the Interior U.S. Geological Survey, 1912, is devoted to a description and illustration of the Pliocene and Pleistocene Foraminifera from Southern California by Rufus M. Bagg. Over a hundred forms are described in ninety-two pages of text, and illustrated in twenty-eight plates by a series of excellent figures. That the author knows his subject is evident from the paucity of 'n.spp.'

6. Bibliography of North American Geology (Petrology and Mineralogy) for 1911.—This useful work, compiled for 1911 by John M. Nickles, was published last year as Bulletin 524 of the Department of the Interior U.S. Geological Survey. It contains 1,266 entries, and has a first-class analytical index.

7. Palæozoic Sediments.—In the *Journal of Geology* (Chicago) for April–May, 1913, is a very suggestive paper by T. C. Brown on the origin of certain Palæozoic sediments. The author discusses the conglomerates, the oolites, and the interbedded sands of the Cambrian and Ordovician rocks of Center County, Pennsylvania. In the same Journal E. S. Bastin has a paper on "Chemical Composition as a criterion in identifying Metamorphosed Sediments", which may be read in conjunction with the preceding.

8. Miocene Fauna of Eggenburg.—Dr. F. X. Schaffer deals with this interesting fauna in the Abhandlung der k.k. geologischen Reichsanstalt, vol. xxii, pt. ii (November, 1912). The paper includes the Gasteropoda, Cephalopoda, Crinoids, Echinoids, and Brachiopoda, and is fully illustrated. The fauna is singularly rich in *Cerithium*, *Turritella*, and *Patella*, and the occurrence of several species of *Antedon* is interesting.

REPORTS AND PROCEEDINGS.

I.—The Royal Society.

June 5, 1913.—Sir Archibald Geikie, K.C.B., President, in the Chair.

The Croonian Lecture was delivered by Dr. Robert Broom, C.M.Z.S., on "The Origin of Mammals".[1]

An endeavour is made to trace the evolution of mammals from Cotylosaurian ancestors through the carnivorous Therapsida. In

[1] The accompanying abstract has been furnished by the author.

Upper Carboniferous times the line probably passed through some primitive generalized Pelycosaurs; in Lower Permian through primitive, probably Therocephalian, Therapsids. In Middle and Upper Permian the line passed through the Gorgonopsia. In Triassic times the mammalian ancestors were small generalized Cynodonts. In Lower Jurassic the mammals are so Cynodont like, and the Cynodonts so mammal-like, that in no single case are we absolutely certain which is which.

In the Therocephalia, the Gorgonopsia, and the Cynodontia, the skull is very mammal-like. The zygomatic arch is, as in mammals, formed by the jugal and the squamosal. The teeth are divided into incisors, canines, and molars. In the later Gorgonopsians there is an imperfect secondary palate; in Cynodonts a complete secondary palate as in mammals. In Permian Therapsids there is a single occipital condyle; in the Triassic Cynodonts there may be a single condyle slightly divided or two exoccipital condyles. There is, on passing from earlier to later types, a steady increase in the size of the dentary and decrease in the size of the other elements of the jaw. The quadrate also becomes much reduced in the higher types. In Gorgonopsians and probably all earlier types the arch of the atlas is a pair of bones; in Cynodonts, as in mammals, there is a single arch.

It is argued that the small Gorgonopsians fed almost exclusively on the comparatively slow-moving, small, herbivorous Anomodonts. In the Trias the small Anomodonts became very rare, and the carnivorous Therapsids had to feed on other small forms, apparently the more active lizard-like Cotylosaurs, such as *Procolophon*. The change of habit resulted in the Cynodontia.

In Upper Triassic times the larger Cynodonts preyed upon the large Anomodont, *Kannemeyeria*, and carried on their existence so long as these Anomodonts survived, but died out with them about the end of the Trias or in Rhætic times. The small Cynodonts, having neither small Anomodonts nor small Cotylosaurs to feed on, were forced to hunt the very active long-limbed Thecodonts. The greatly increased activity brought about that series of changes which formed the mammals—the flexible skin with hair, the four-chambered heart and warm blood, the loose jaw with teeth for mastication, an increased development of tactile sensation, and a great increase of cerebrum. Not improbably the attacks of the newly evolved Cynodont or mammalian type brought about a corresponding evolution in the Pseudosuchian Thecodonts which ultimately resulted in the formation of Dinosaurs and Birds.

II.—Geological Society of London.

(i) *May* 28, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The President, in referring to the loss which the Society had that day sustained by the decease of John Lubbock, 1st Baron Avebury, recalled the fact that Lord Avebury had been a Fellow of the Society for no less than fifty-eight years, that he had contributed several valuable papers to the Society's Journal, and that he was the recipient

of the first Prestwich Medal. The President added that he felt sure that the Fellows would associate themselves with the resolution of condolence and sympathy which the Council had addressed to Lady Avebury.

The following communications were read:—

1. "On the Age of the Suffolk Valleys; with Notes on the Buried Channels of Drift." By Percy G. H. Boswell, B.Sc., F.G.S.

The main watershed of Suffolk follows generally the Chalk escarpment, but keeps rather to the east of it, running in a north-easterly direction from Haverhill in the extreme south-west of the county. Suffolk forms a plateau, 100 to 400 feet O.D., dissected by a valley-system which is palmate in form, the chief rivers, taken from north to south, being the Waveney, the Alde, the Deben, the Gipping (with its estuary, the Orwell), the Brett, and the Stour. The Little Ouse and the Lark flow north-westwards into the Wash basin.

The strata (Chalk, Lower London Tertiaries, London Clay, Crags, etc.) cut through by the valleys, and the mantle of glacial deposits (sands, gravels, and loams, Upper Boulder-clay, and morainic gravels), which more or less covers the whole county, are described briefly. Reasons are given for thinking that the Contorted Drift does not extend far south of the Waveney. The valleys, although they may have been etched earlier, are on direct evidence post-Pliocene in age; but, by analogy with the Waveney and the Norfolk rivers, they may be younger than the Contorted Drift.

The Upper Boulder-clay (= the Great Chalky Boulder-clay of S. V. Wood, jun.) covers much of the plateau, and wraps down into the valleys in a very characteristic manner. The glacial Sands, etc., below it also appear at times to lie on the valley-slopes. Intense glacial disturbances are found to be situated always on 'bluffs' or 'spurs' of the plateau projecting into the wide open valleys, which were thus in existence before the advent of the valley glaciers to the action of which the disturbances have been attributed.

In each of the main valleys occur one or more buried channels of Drift; borings made recently allow these to be described in detail, and the deposits filling them to be discussed. A contour map of the top of the Chalk is prepared for the county, and this serves to bring out the anomalies in the valleys. These buried channels were probably eroded by sub-glacial water-streams, and a comparison is instituted between them and the Föhrden of North Germany, Schleswig-Holstein, Kerguelen, etc., described in detail by Dr. Werth and others.

The evidence, therefore, indicates that the pre-Glacial or early Glacial contours of Suffolk were in the main much as they are now. The form of the rivers and valleys suggests that some amount of capture may have taken place before the deposition of the Upper Boulder-clay; and that the present river-system is recovering from a state of arrested development, due to the 'overloading' of the valleys with Drift deposits and torrential debris during the last glaciation of the area, and to the subsidence (some 60 to 80 feet) which followed it.

2. "The Internal Structure of Upper Silurian Rugose Corals from the Grindrod Collection, Oxford Museum." By Donald Esme Innes, B.A. (Communicated by Professor W. J. Sollas, Sc.D., F.R.S., F.G.S.)

In this paper the following genera and species are described:—

Palæocyclus porpita, P. fletcheri, P. rugosus.
Cystiphyllum siluriense, C. cylindricum.
Cyathophyllum (?): a new species.
Cyathophyllum articulatum, C. truncatum.
Strombodes murchisoni, Str. typus, Str. diffluens.

The new species of *Cyathophyllum* (?) is of especial interest. It was figured by Milne Edwards & Haime as *Cystiphyllum cylindricum*, Lonsdale, with which it has no close affinities. It combines characters of the Silurian *Cyathophylla* and *Hallia* with those of the Lower Carboniferous *Caniniæ*.

Particular attention is paid to the construction of a septum in the various genera, the following types being well represented:—

(1) Radial spines on the vesicles, with their bases often connected by a web. Example: *Cystiphyllum*.
(2) Rods placed in juxtaposition and cemented together. Example: *Palæocyclus*.
(3) Simple plates. Example: *Cyathophyllum articulatum*.
(4) Crumpled plates. Example: *Cyathophyllum* (?), the new species.
(5) Plates with backward costal prolongations. Example: *Strombodes*.

Comparison of the Upper Silurian coral facies with that of the Lower Carboniferous shows that *Cystiphyllum*, in its vesicular and spinose structure, bears a close resemblance to the compound *Michelinia*, while *Strombodes* is allied in structure to *Cyathophyllum regium* of the Viséan.

(ii) *June* 11, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The following communications were read:—

1. "Certain Upper Jurassic Strata of England." By Dr. Hans Salfeld, University of Göttingen. (Communicated by S. S. Buckman, F.G.S.)

The writer has studied the Upper Jurassic strata of North-Western Germany, the Boulonnais, and Southern England with special reference to the Ammonites and their zones. The results of his labours are to be published in detail; but, in anticipation, he offers to the Society an epitome of his conclusions with regard to the English strata.

The localities with which he deals are the Dorset coast from Kimmeridge to Abbotsbury, and the Wiltshire exposures at Swindon and Westbury, with an incidental reference to Market Rasen. The formations concerned are the Portlandian, Kimmeridgian, and for a starting-point the Upper Oxfordian: these terms being employed in the German sense. The Upper Oxfordian = upper part of the English Corallian (+ Kimmeridge Clay locally) is divided into three zones, found at Osmington, Westbury, and Swindon. The Kimmeridgian is divided into five zones, and is equal mainly to the Lower Kimmeridge Clay of English authors, with one important exception;

the Abbotsbury Iron-ore is placed as the second zone of the Kimmeridgian, and is correlated with the Market-Rasen Clays. The Portlandian is divided into nine zones; but the term as used in the paper includes the Portland Oolites, Portland Sands, and Upper Kimmeridge Clay of English authors.

Three new genera of Ammonites are named, and two new zonal species of Ammonites are defined.

2. "The Volcanic Rocks of the Forfarshire Coast and their Associated Sediments." By Albert Jowett, M.Sc., F.G.S.

The peculiar intermingling of fine sediments with the Lower Old Red Sandstone lavas of Scotland is well known from the writings of Sir Archibald Geikie.

The author has found that in Forfarshire these sediments are frequently amygdaloidal, the production of the cavities having been accompanied by the buckling and fracturing of the layers of sediment. It is suggested that such effects may result from the pouring of molten rock over wet unconsolidated sediment: steam being produced within the sediment, but unable to escape owing to the presence of the overlying rock. The surface of the sediment was apparently ploughed up by the lava, the lower portion of which occasionally contains rounded nodules of hard amygdaloidal sediment. The sediment is sometimes slightly altered where in contact with the volcanic rock.

Further evidence of the pouring of molten rock into water is furnished by the occurrence of a rude pillow-structure in some of the lavas.

Several lenticular conglomerates are interbedded with the volcanic rocks, resting upon eroded surfaces of the latter. The conglomerates consist of large rounded blocks of volcanic rock, enclosed in a matrix composed almost entirely of volcanic debris.

Most of the volcanic rocks are olivine-basalts, rhombic pyroxene as well as olivine sometimes being present. Some contain rhombic pyroxene to the exclusion of olivine. A few porphyrite dykes of Lower Old Red Sandstone age are intruded in the lavas.

The fine sediments consist of a variable proportion of quartz and mica and a little felspar, together with chlorite, iron oxides, and occasional minute fragments of volcanic rock.

Calcite, quartz, chalcedony, and chlorite are the commonest minerals in the amygdules, in both lavas and sediments.

In the south-west of Lunan Bay, a mass of Upper Old Red Sandstone with a basal conglomerate has been found resting unconformably upon the Lower Old Red Sandstone volcanic rocks.

3. "On a group of Metamorphosed Sediments situate between Machakos and Lake Magadi in British East Africa." By John Parkinson, M.A., F.G.S.

That part of British East Africa which borders the Athi Plains and extends westwards to the eastern edge of the Rift Valley, is undulating country composed of foliated rocks of ancient appearance, crossed by pegmatites which are unconnected with any apparent granitic intrusions.

A series of crystalline rocks, for which it is proposed to use the name Turoka Series, is situated just below the great lava plateau of the Kapiti Plains, and forms the ground drained by the head-waters of the Turoka River. The following rock-types are present in the chief section, in the following apparent upward succession :—

(1) Hornblende-schist, seen to a thickness of 3 ft. 5 in. ; (2) flaggy and impure marble, 3 feet ; (3) biotite-gneiss, 2 feet ; (4) calc-mica rock with lenticles of biotite-gneiss, 3 ft. 8 in. ; (5) hornblende-schist similar to No. 1, 1 foot ; (6) impure calc-rock, 2 feet ; (7) quartz-felspar vein, 2 feet ; (8) hornblende-schist, 2 feet ; and (9) impure calc-rock, resembling No. 5 and about 4 feet thick.

A detailed petrographical description is given of the various rock-types present in the series, which, in addition to those mentioned above, includes kyanite-garnet-gneisses and a scapolite-garnet rock.

The author concludes that the group represents a series of metamorphosed arenaceous and calcareous sediments, and that there is a complete passage from calc-mica rocks into biotite-gneisses.

Mineralogical Society.

June 17.—Dr. A. E. H. Tutton, F.R.S., President, in the Chair.

W. L. Bragg : Crystal Structure as revealed by Röntgen Radiation. An analysis of the diffraction patterns obtained when X-rays traverse a section of a crystal shows that in many simple crystals the diffraction is caused by a set of points arranged on a space-lattice. This is the case when the molecule contains either a single heavy atom of at least twice the atomic weight of the other constituents, or only two atoms of nearly the same atomic weight. By comparison of the pattern given by certain alkaline halides, such as K C l and K Br, a definite structure of these cubic crystals is clearly indicated, and it would appear that the atoms are arranged on a space-lattice whose elementary parallelopiped is a cube, alternate atoms being along the axes, so that atoms of one kind form a face-centred cubic space-lattice. These conclusions are confirmed by a comparison of the distances between planes parallel to the various faces of these crystals carried out by means of the X-ray reflection-spectrometer, and it appears that a single atom is associated with each point of the space-lattice which diffracts in the case, for instance, of the alkaline halides, calcite, fluor, blende, and pyrites. If the suggested structure of the crystals is correct, a simple calculation gives the absolute wave-length in centimetres of the homogeneous components in the X-ray beam from a platinum anticathode.—H. V. Ellesworth : The Crystal Habit of Topaz from New Brunswick, Canada. Topaz, a rare mineral in Canada, occurs in York Co., New Brunswick, associated with wolframite, molybdenite, and a little fluor. On the crystals the forms 110, 120, 011, 112 are prominent, but other pyramid and prism forms are sometimes present, sixteen forms altogether being observed. Dull faces were coated with silver by Brashear's process, in which an ammoniacal solution of silver nitrate is reduced by a sugar solution.—Dr. G. T. Prior : On the Meteoric Stone which fell at Baroti, Punjab, India, in September, 1911. The stone,

which belongs to the 'intermediate chondrite' group of Tschermak's classification, was found on analysis to contain about 9 per cent of nickel-iron and 7 per cent of troilite, which were disseminated in small particles through a colourless matrix of enstatite and olivine showing only few chondrules.—Dr. A. W. Gibb exhibited kämmererite from Unst, Shetland Islands.

IV.—Zoological Society of London.

May 20, 1913.—Professor E. A. Minchin, M.A., F.R.S., Vice-President, in the Chair.

Dr. R. Broom, C.M.Z.S., read a paper "On the South African Pseudosuchian Reptile *Euparkeria* and allied Genera". Besides giving an account of the very completely known South African form, he also discussed the structure of the Elgin allied forms, *Ornithosuchus* and others. The group of Pseudosuchians he regarded as an extremely important primitive reptilian order, as there is good reason to believe that not only does it contain the ancestor of the Dinosaurs, but also the ancestors of the Pterodactyles and Birds. *Euparkeria* and *Ornithosuchus* are, in structure, almost Dinosaurs, and it is held that when the bipedal habit was more fully acquired the few characters not quite Dinosaurian would become Dinosaurian. Birds are held to have originated from a Pseudosuchian which, by a bipedal habit, had acquired a Dinosaur-like hind limb, and had then become arboreal in habit and acquired the peculiar power of flight.

June 3, 1913.—Professor E. W. MacBride, M.A., D.Sc., F.R.S., Vice-President, in the Chair.

A paper on "Some Miocene Cirripedes of the genera *Hexelasma* and *Scalpellum* from New Zealand", communicated by Dr. W. T. Calman, F.Z.S., was read by Mr. T. H. Withers, F.G.S. An account is therein given of the 'gigantic Cirripede' of New Zealand, originally described as *Scalpellum aucklandicum*, of which remains have long been known to occur in the Waitemata Beds (Miocene) of Motutapu Island, Auckland Harbour. The valves of this Cirripede attain a length of 8 inches, and have been previously supposed to belong to a pedunculate form, but while Sir James Hector (1887) referred them to the genus *Scalpellum*, Professor W. Blaxland Benham[1] (1903) thought that they approached more closely to the genus *Pollicipes*. From a study of the original material collected by Professor James Park (1887), it is now shown that this Cirripede is a sessile form allied to *Balanus*, and it is referred to Dr. P. P. C. Hoek's recently instituted genus *Hexelasma* (1903). A smaller undetermined species of *Hexelasma* and a new species of *Scalpellum* (*sensu lato*) are also described. These are in the collection of the Geological Survey, New Zealand, and occur in the same beds as the 'gigantic Cirripede'.

A second new species of *Scalpellum* is founded on some valves from New Zealand, and a restoration is given, the remains being sufficient to justify their reference to the sub-genus *Arcoscalpellum*, Hoek.

[1] Geol. Mag., 1903, p. 110, Pls. IX, X.

OBITUARY.

THOMAS FRANCIS JAMIESON, LL.D., F.G.S.

BORN APRIL 26, 1829. DIED MAY 24, 1913.

WE regret to record the death of T. F. Jamieson, of Ellon, Aberdeenshire, distinguished for his researches on the glacial geology of Scotland. The results of his earliest geological work and of all his more important subsequent observations were communicated to the Geological Society of London, introduced in the first instance by Murchison in 1858. Four years later Jamieson was elected a Fellow of the Society, and in 1898 he was awarded the Murchison Medal by the Council. On that occasion, although unable to be present, he wrote expressing his gratification and his "recollection of the warm-hearted Sir Roderick", from whom he had received much kind attention and help many years ago when a young man.

Jamieson was born at Aberdeen, and educated at Marischal College during the years 1843–6, but he did not graduate. His energies were now devoted to rural economy. For many years he was Factor on the Ellon estate, and subsequently took the farm of Mains of Waterton, and became widely known and respected as an expert in agricultural matters. In 1862 he was appointed Fordyce Lecturer on Agricultural Research in the University of Aberdeen, his services being recognized in 1884 by the conferment of the honorary degree of LL.D.[1] Meanwhile his leisure time was occupied with studies of the various Drift deposits and the effects of glacial action. In his first paper, on the "Pleistocene Deposits of Aberdeenshire" (read in 1858), he described various mounds and ridges of gravel and the shells from the drifts, which in his opinion were accumulated at a time when the land was 450 feet lower. Subsequently it stood higher than it does now.

In another paper (1860) on the "Drift and Rolled Gravel of the North of Scotland", he dealt more fully with the Pleistocene phenomena, and for the first time brought forward detailed evidence relating to the land-glaciation of Scotland, to the fluting, grooving, and scratching of the rocks, the dispersion of boulders, etc. Interesting observations were also recorded on the positions assumed by pebbles in streams.

In the same year he drew attention to the occurrence of characteristic Crag shells in the Drift of Aberdeenshire, and regarded the evidence as indicating a patch of Crag preserved in situ. In 1882, in a further account, he gave reasons for believing that the shells were derived.

In 1862, in a paper on the "Ice-worn Rocks of Scotland", he pointed out the great erosion by ice-action, and the presence of boulders far above their parent rocks. He illustrated his remarks on land-ice by reference to phenomena in Greenland and on the Antarctic continent, and gave a sketch-map of Scotland showing the direction of the glacial markings.

[1] For these particulars we are indebted to the *Aberdeen Free Press*, May 26, 1913.

In 1863 his great paper on the "Parallel Roads of Glen Roy" was published, and therein he showed that they are beaches of freshwater lakes, which originated from glaciers damming the mouths of valleys and reversing their drainage. The date of the lakes he regarded as posterior to the great land-glaciation of Scotland.

As remarked by Lyell (*Antiquity of Man*, 4th ed., p. 305), Mr. Jamieson "observed many facts highly confirmatory of the theory of glacier-lakes", which had been previously suggested by Agassiz and Buckland, and "showed that this theory affords a complete explanation of all the most striking peculiarities".[1]

In 1891 he published "Supplementary Remarks on Glen Roy", dealing with subsequent explanations and further supporting his original views.

In 1865 he read an important paper on the "History of the Last Geological Changes in Scotland". In this he referred to evidence of the Mammoth having inhabited Scotland before the Glacial period. He noted the enormous thickness of the land-ice, Schiehallion (3,500 feet high) being glaciated near to the top as well as on its flanks. He considered that the ice was developed as a thick cake and flowed off "not so much on account of the inclination of the bed on which it rested", but "in the way that a heap of grain flows off when poured down on the floor of a granary . . . given a floor of infinite extension, and a pile of grain of sufficient amount, the mass would move outward to any distance". He concluded that "the want of much inclination in the surface of a country, and the absence of great Alpine heights, are therefore objections of no moment to the movement of land-ice, *provided we have snow enough*".

He further noted how the Boulder-clay varies in colour and character according to the rocks from which it was derived, and he expressed his opinion that certain kaims (or kames) may have been formed by the ridging-up of gravel in front of a glacier.

Finally, he discussed the introduction of the plants and animals into the British Isles since the Glacial period, admitting that "ice might have formed a bridge to some, but not to the greater part". This paper contains a long list of Glacial shells.

In 1866 he described the "Glacial Phenomena of Caithness", and in 1874 he dealt with the "Last Stage of the Glacial Period in North Britain", discussing the formation of kaims and eskers, and advocating the development of a second ice-sheet, but not so thick nor so extensive as that in the earlier glaciation. In 1882 he read a paper on the "Red Clay of Aberdeenshire", considering that it was laid down before the last advance of the glaciers.

We need only further mention that Mr. Jamieson on two occasions entered other geological fields, writing in 1861 on the "Structure of the South-West Highlands of Scotland (parts of Bute, Cowal, and Jura)", and in 1871 on the "Older Metamorphic Rocks and Granite of Banffshire", when he advocated the metamorphic origin of the granite, and was supported by Ramsay.[2] H. B. W.

[1] See also E. B. Bailey, Proc. Geol. Assoc., xxii, 203, 1911.

[2] Seventeen papers, from 1865 to 1908, are credited to Mr. T. F. Jamieson in the GEOLOGICAL MAGAZINE.—ED.

THE RIGHT HON. BARON AVEBURY,
D.C.L., LL.D., F.R.S., F.L.S., F.G.S., Etc.

Born April 30, 1834. Died May 28, 1913.

In the death of Lord Avebury natural science has lost one of its most enthusiastic and cultured disciples. Born at Eaton Place, London, he was the son of Sir John William Lubbock, 3rd Baronet, F.R.S., F.G.S., a distinguished mathematician and astronomer, who died in 1865. John Lubbock succeeded to the baronetcy in that year, and was created Baron Avebury in 1900. He received a school education at Eton, but no University training, as his services were wanted before he had attained the age of 15 in the banking-house of Robarts, Lubbock & Co., Lombard Street, an establishment of which his father was then the Head. John Lubbock became a partner in the firm in 1856 and succeeded to the chief position on the death of his father. It will be unnecessary here to refer in particular to his great business capacity and to the services he rendered to commerce, the arts, and to education in general. As a Member of Parliament he represented Maidstone and afterwards the University of London, taking an active part in promoting the Ancient Monuments Act, the Open Spaces Act, and many other measures.

Interest in the study of natural history was developed in Lubbock at an early age, and the proximity of his home at High Elms, near Farnborough, to that of Darwin at Down, in Kent, no doubt greatly influenced the character of his recreative pursuits. In course of time he acquired a wide range of knowledge in archæology, entomology, botany, and geology, and we may be content here to refer to his researches on the first and last of these subjects.

One of his earliest discoveries, made in 1855 in company with Charles Kingsley, was that of the skull of a musk-ox in a gravel-pit close to Maidenhead railway station, and the specimen was described by Owen in the following year as the first example which had come under his notice from a British locality. In 1860 and again in 1862 and 1863 he joined Prestwich and others in excursions to the flint-implement-bearing districts of Amiens and Abbeville, and in 1861 he spent a holiday in Switzerland with Tyndall and Huxley. The knowledge thereby obtained stimulated those further studies which led in one direction to the publication in 1865 of Lubbock's *Prehistoric Times, as illustrated by Ancient Remains and the Manners and Customs of Modern Savages*. This work was followed in 1870 by *The Origin of Civilisation and the Primitive Condition of Man*. Both works have attained to the sixth edition. It may further be mentioned that he was associated with Huxley, Busk, and others as one of the editors of the *Natural History Review* (1861–5). In 1867 he brought before the Geological Society a paper "On the Parallel Roads of Glen Roy", advocating their formation in a lake, the waves in which did not arrest but threw down to lower levels the angular debris of the hill-slopes. His interest in Switzerland led to many journeys to that country and to the publication in 1896 of *The Scenery of Switzerland and the Causes to which it is due*. Of this work a fourth edition has been issued. A companion volume on

The Scenery of England and the Causes to which it is due was published in 1902, and the subject, beautifully illustrated, clearly expounded, and treated in an enthusiastic spirit, made the work so popular that it has reached a fifth edition.

In 1903 Lord Avebury gave to the Geological Society the results of "An Experiment in Mountain-building", based on apparatus which produced compression in two directions. The features thus produced on pieces of carpet-baize and alternating layers of sand were illustrated in his short published account of the phenomena.

He was elected a Fellow of the Geological Society in 1855, and in 1903 the Council awarded to him the first Prestwich Medal. He was elected a Fellow of the Royal Society in 1858, and became a Trustee of the British Museum in 1878, taking a warm interest in its affairs, and especially in the Natural History branch, afterwards established in South Kensington. He was chosen president of many societies representing diverse scientific and practical subjects, among them the Linnean, Royal Microscopical, Ray, Entomological, and Statistical Societies, and the Anthropological Institute. As the representative of many sciences he was fitly selected to preside over the jubilee meeting of the British Association held at York in 1881.

Lord Avebury was twice married, his second wife being daughter of General Pitt-Rivers, F.R.S. He died at his seaside residence, Kingsgate Castle, near Margate, and was buried on May 31 at Farnborough churchyard, Kent. He is succeeded in the Peerage by the Hon. John Birkbeck Lubbock, his eldest son.

HERBERT KELSALL SLATER, F.G.S.

BORN AUGUST 28, 1875. DIED MAY 2, 1913.

WE regret to record the death from snake-bite of Mr. Herbert Kelsall Slater, F.G.S., Assistant Geologist and Acting Second State Geologist to the Mysore Government. He was the son of the Rev. T. E. Slater, a well-known missionary in Mysore, and was educated at Bishop's Stortford College, Herts, and the Central College, Bangalore. In October, 1894, he joined the newly formed Mysore Geological Department under Mr. Bruce Foote, and afterwards served under his successors, Dr. J. W. Evans and Dr. W. F. Smeeth. He had already acquired a competent knowledge of geology in India when he returned to England in 1901 and studied at the Royal College of Science under Professor J. W. Judd. In 1909 he again visited this country for purposes of study, and afterwards spent some months in Canada and made himself familiar with its crystalline rocks, as these present many points of similarity to those on which he was working in India. He mapped a considerable portion of Mysore, especially in the Shimoga, Tarikere, and Kadur Districts, which lie in the north and west of the State, and brought an independent mind to the problems that presented themselves. His work will be found in the Records of the Mysore Geological Department. See vol. ii, pp. 118–30, 1899; vol. iii, pp. 148–62, 1901; vol. iv, pp. 119–46, 1903; vol. v, pt. ii, pp. 35–56, 1904; vol. vi, pt. ii, pp. 5–26, 1905 ('intrusive' and 'corrosive'

quartz); vol. vii, pt. ii, pp. 1–20, 1906 (describing a remarkable conglomerate in the schists between Birur and Tarikere); vol. viii, pp. 31–72, 1907 (iron-bearing rocks associated with charnockite); vol. ix, pp. 35–72, 1908 (banded magnetite quartzites). He also reported to the Government on various metalliferous deposits and building stones.

On the morning of his death, Mr. Slater was at a short distance from his camp near Tirthahalli, in the Shimoga District, when he trod upon a large snake, which coiled itself round his boot and bit him repeatedly under the knee through stout cord breeches. Death took place some twelve hours later. Mr. Slater leaves a widow and three young children. J. W. E.

LESTER FRANK WARD, A.M., LL.D.

We learn from *Nature* that Dr. Lester Frank Ward, A.M., LL.D., Professor of Sociology at Brown University, Providence, R.I., and formerly Palæontologist of the U.S. Geological Survey, died in Washington on April 18, in his 72nd year. He was born in 1841 at Joliet, Illinois, and was known to geologists more especially by his researches on the Flora of the Laramie Group, which he regarded as having equally Upper Cretaceous and Lower Tertiary affinities.

ERNST ANTON LEOPOLD KITTL.

Born December 2, 1854. Died May 1, 1913.

The death is announced of Professor Ernst Kittl, who was for many years associated with the geological and palæontological department of the Imperial Court Natural History Museum of Vienna, first as assistant and ultimately as director. In 1885 he published two papers on the Lower Pliocene Mammalia of Maragha, Persia, and during subsequent years he prepared numerous other important papers on fossils, chiefly Mollusca. He also wrote a Guide Book to the Geology of the Salzkammergut, for the use of the International Geological Congress which met in Vienna in 1903.

WILLIAM FOX, M. INST. C. E.

We regret to record the death on June 14, aged 66, of William Fox, M. Inst. C. E., M. Inst. Mech. E., an eminent waterworks engineer, whose labours naturally brought him into association with various geological problems. For many years he was a Fellow of the Geological Society, but had recently resigned.

MISCELLANEOUS.

Mr. Charles Panzetta Chatwin, of the Geological Department of the British Museum (Natural History), has been appointed Assistant Librarian to the Geological Society of London. Mr. Chatwin carries with him the cordial wishes of his friends, who feel that his many qualifications will in time allow him to settle down into a long career of usefulness to the Fellows of the Society.

Portion of a trunk of *Lepidodendron veltheimianum*, Sternb., from French, Lick, Indiana. ½ nat. size.

THE

GEOLOGICAL MAGAZINE

NEW SERIES. DECADE V. VOL. X.

No. VIII.—AUGUST, 1913.

ORIGINAL ARTICLES.

I.—Note on a Process of Fossilization in the Palæozoic Lycopods.[1]

By E. M. Kindle, Department of Mines, Geological Survey of Canada, Ottawa, Ontario.

(PLATE XI.)

Most collections of fossil plants include specimens of tree-trunks or branches in which the bark is preserved in great perfection, while no trace of the structure of the trunk within the bark remains. Striking examples of this type of fossilization, in which the bark is preserved in exquisite detail while the space within the bark is wholly filled with fine siliceous sediments showing no trace of the original plant structure, occur frequently among the various species of *Sigillaria* and *Lepidodendron*. The fossilized armour-like outer cortex of *Lepidodendron* fails to retain any remnant of the inner woody material about as often as the various molluscan species of *Spirifer* fail to preserve their delicate internal spires. We know from the silicified specimens which have been found that the greater part of the trunk in *Lepidodendron* is occupied by a soft middle cortex which is very readily disposed of by micro-organisms. The relatively small cylinder of secondary wood which is found in most species which have attained to a large growth was itself rather susceptible to decay, the tracheids being relatively thin-walled, with the medullary cells very large and the rays voluminous.[2] Innumerable examples of the entire failure of the woody tissue of these Lycopods to survive the processes which left the outer cortex admirably preserved occur in the fine-grained sandstones of Pottsville age in Orange County, Indiana. These beds, which have long been quarried for the manufacture of whetstones, contain numerous fossil trunks of *Lepidodendron veltheimianum*, Sternb. (Plate XI), which show the carbonized bark in a good state of preservation, while the space inside the bark is wholly filled with very fine sand similar to that of the strata in which the fossils lie. These sand-filled tree-trunks generally retain approximately their original outline, except for a slight flattening of the trunk. Two trunks of *Lepidodendron* about 10 inches in diameter and 8 feet in height were observed at the time of my visit standing upright in one of the whetstone quarries. The largest trunk seen had a circumference of 4 ft. 8 in. The usual size of the trunk is 6 to 15 inches in

[1] Published with the permission of the Director of the Geological Survey of Canada.

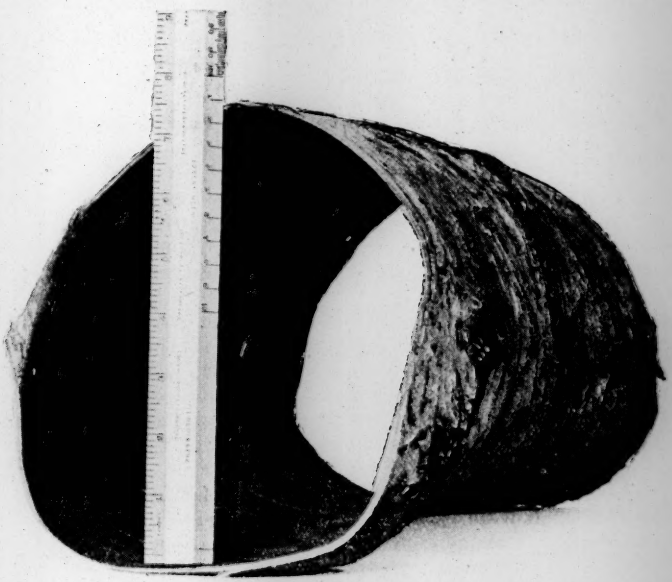
[2] Letter to the author from David White.

diameter. None of the trunks observed in the whetstone quarries, whether large or small, showed any trace of woody tissue within the bark, which was usually altered to coal. Similar sand-filled trunks of *Lepidodendron* and *Sigillaria* have been described by Dawson from Joggins, Nova Scotia, and by various geologists from other localities. The exact conditions under which the substitution of sand for woody tissue within the bark occurred during the fossilization of the latter have, so far as the writer is aware, never been illustrated by examples from our present forests. Rational explanations of the obscure phenomena of the past are often facilitated by means of the analogy supplied by existing agencies. I may therefore venture to call attention to the remarkable resistance to decay of the bark of the common canoe-birch and the equally striking susceptibility to decay of the wood of this tree. Consideration of the differential rate of decay of the bark and the wood of the birch throws much light on the process which has so often produced the kind of fossilization represented by the sand-filled bark of the *Lepidodendron*.

The decay of wood is essentially a biological process resulting directly from the metabolism of the fungi and bacteria which gain access to it. But since moisture and free oxygen are essential to the life of these organisms, wood kept either in a very dry atmosphere or under water is practically immune from decay. The protective agency of water is illustrated by the fact that many of the oak piles in a certain town in Wales which were used in the construction of a dock five hundred years ago are still doing service. It seems clear that the degree of resistance of various kinds of woods to decay depends primarily not upon the texture of the woody tissue but upon the presence or absence of substances in it which fail to support or are directly harmful to the life of destructive fungi. Thus pitch and resin in the soft wood of the conifers and tannin in the cells of the oak are unfavourable to the growth of fungi. During life the bark of all trees is highly resistant to colonization by either fungi or bacteria, and until broken affords complete immunity from their attacks on the enclosed wood. After the death of the tree, however, the bark in many species loses the qualities which made it while the vital processes were active immune to the vital activities of fungi and micro-organisms, and decay may proceed in it much more rapidly than in the wood. This is true in the case of the walnut, beech, tulip, and many other trees where the bark completely decays or breaks up into small fragments while the wood is still in a good state of preservation. In the case of the birch, however, the immunity to decay which characterizes the bark of all living trees persists to a remarkable degree after death. So great is this resistance in the canoe-birch, *Betula papyracea*, that the wood may completely disappear while the bark is still in a perfect state of preservation and retains the original shape of the tree-trunk.

The photograph (Text-figure) shows a section of the bark of a birch-tree from Manitoba in which the wood had almost completely decayed and disappeared. This bark shell which retained but a trace of decomposed woody dust, however, is wholly untouched by decay, and similar examples may be observed wherever birches flourish.

Another section of a small birch-tree represented by perfectly preserved bark from which the wood had wholly disappeared illustrates well the possibilities which the birch affords for the formation of sand-filled fossil tree-trunks similar in their general features to those of the Palæozoic Lycopods. This was found nearly filled with sand and partially buried in a river bar. The density of the bark of the birch is such that a section of it remains almost completely submerged when in the water. This characteristic would facilitate its speedy sinking and burial in sediment whenever subjected to fluvial action. The birch-bark specimen shown in the figure has suffered a slight flattening, resulting from the decay and removal of the supporting wood. It should be noted that this slight flattening of the birch-bark is duplicated very often in the fossilized trunks of *Lepidodendron*. The



Section of the bark of the trunk of the canoe-birch from which the wood has completely decayed, but leaving the bark in a nearly perfect state of preservation.

partially sand-filled section of birch-bark just alluded to clearly illustrates how perfectly one of the trees of our present flora combines in itself characteristics which would lead to the same kind of fossilization so often met with in *Lepidodendron*. Observations of the empty bark shells of decayed birch-trees in the Canadian forests can hardly fail to convince one that *Lepidodendron* possessed a bark which, like that of the birch, far outlasted the woody interior. It appears most probable that the bark cylinders of the fossil Carboniferous Lycopods were generally hollowed out by rapid decay of the wood and then filled with sediment before fossilization began, just as empty birch-bark

tree-trunks are now being prepared for fossilization in Canadian lakes and rivers.[1]

[*Note.*—Excellent sound timber for gate-posts and other agricultural purposes is obtained both in Scotland and Ireland from the perfectly preserved bog-oak and other trees found in the peat. The piles of the Swiss lake-dwellings (of Stone and Bronze age) testify by their soundness the durability of wood under water, the only important change being their *blackened* condition.—Ed.]

EXPLANATION OF PLATE XI.

Portion of a trunk of *Lepidodendron veltheimianum*, Sternb., from French, Lick, Ind. ½ nat. size.

The specimen represents a mould composed of fine siliceous sediments which have been deposited inside a section of empty bark trunk. A portion of the original carbonized bark which still adheres to the mould is seen in the dark irregular patches.

II.—*Micropholis Stowi*, Huxley, a Temnospondylous Amphibian from South Africa.

By D. M. S. Watson, M.Sc., Lecturer in Vertebrate Palæontology in University College, London.

Micropholis Stowi was described by Huxley in 1859 from a small and very incompletely preserved skull found by G. W. Stow at Rhenosterberg (north-west of New Bethesda), District Graaf Reinet, Cape Colony. Subsequently R. Owen described another specimen as *Petrophryne granulata*. In his description he suggested that it might prove to be identical with Huxley's type. The British Museum now contains these two type-specimens and three other examples of the form, all except Huxley's type being from the *Procolophon* zone of Donnybrook, Upper Zwartkei, District Queenstown.

Owen's excellent description and beautiful figures have already made clear the general structure of the roof of the skull, but it is now possible to make out some more sutures, all of which are represented in Fig. 1. The most remarkable features are—

1. The small bone between the premaxillæ. This is a small bone with the same ornament of tubercles as the other skull bones, lying rather loosely in a small fenestra left between the internasal processes of the premaxillæ. The fenestra is present in the three specimens which show this region, and in one small skull it is not filled with a bone. I can find no exact parallel for this bone, but in two types, *Sclerocephalus Roemeri* (H. v. Meyer) and a small Stegocephalian.

[1] Dr. G. R. Wieland, who kindly read the MS. of this paper, has furnished the following interesting memorandum: Indeed, it is curiously in accord with the foregoing facts that in the Palæozoic the thin rind of bark not only tended to outlast the wood in various types, but in turn sometimes aided in the conservation of lesser stems subsequently floated into the bark cavity. In the Laggan Bay bark cylinder figured by Seward no less than five of these floated-in *Lepidodendron* stems appear in fair conservation, while the fact that the cuticular layer must have been remarkably resistant is fully attested by the well-known occurrence in the Permian of Tonea of the thin bands of "paper coal", made up as shown by Weiller of the little-changed and readily stained cuticles of *Bothrodendron*.

(cf. *Ricnodon*), (B.M.N.H. R. 2818) from the Permian Gas Coal of Nyran, Bohemia, there is a small median element in the roof of the skull between the nasals and frontals. I propose to call the anterior of these bones, that which occurs in *Micropholis*, the internasal and the other the interfrontal. Their occurrence is interesting in connection with the median bones so commonly found in the skulls of Dipnoans, which are remotely allied to the Tetrapods.

2. There is a distinct septomaxillare shown on each side in two specimens. It is a little curved plate of bone lying inside the nostril and articulating by its outer edge with the lachrymal. This bone has only once been recorded before in a Stegocephalian, in *Eryops* by Case; it also occurs in '*Bothriceps*' *Huxleyi*.

3. The arrangement of the bones round the orbit is extremely unusual. The lachrymal is a large bone entering into the borders of the orbit and nostril; this condition, which obtains in many primitive reptiles, is very rare in Stegocephalia. Four of the skulls show very

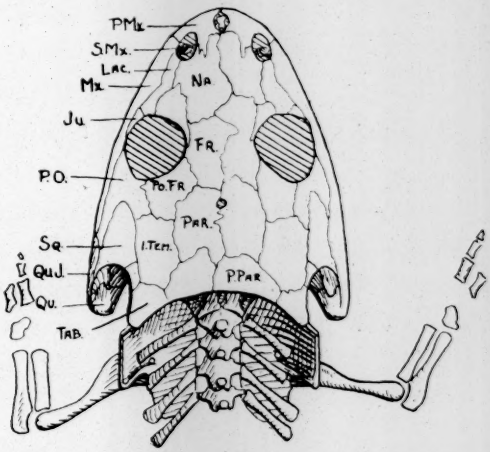


FIG. 1. *Micropholis Stowi*, Hux. Dorsal surface of anterior part of skeleton. × 1. Skull with all sutures on upper surface from R. 510. Vertebræ, ribs, shoulder-girdle, humeri from R. 510*a*. Forearm and hand and quadrate from specimens in the Geological Society's Collection. *Fr.* frontal; *I.Tem.* intertemporal; *Ju.* jugal; *Lac.* lachrymal; *Mx.* maxilla; *Na.* nasal; *P.Mx.* premaxilla; *P.O.* post-orbital; *P.Par.* post-parietal; *Par.* parietal; *Po.Fr.* post-frontal; *Qu.* quadrate; *Qu.J.* quadrato-jugal; *S.Mx.* septo-maxilla; *Sq.* squamosal; *Tab.* tabular.

clearly the course of the ductus naso-lachrymalis (Text-fig. 2), which is a narrow canal running in the substance of the lachrymal bone from the orbit, which it leaves by two openings, to the nostril, where it opens below and behind the septomaxilla. This is, I believe, the first recognition of a ductus naso-lachrymalis in the Stegocephalia, and the occurrence is very interesting from several points of view—

(*a*) The very superficial position of the duct. In development in recent types this begins merely as an epidermal thickening which grows down into the head and subsequently acquires a lumen; in

Micropholis we have an early condition where the duct is still in the skin and has not yet sunk at all deeply.

(*b*) The very great forward extension of the duct and its very unusual exit, practically on the outer surface and just behind the septomaxilla, are of interest. The duct only occurs in Tetrapoda, never in fish, and its origin is obscure; it may be suggested that it is possible that it has been derived from one of the lateral line canals so commonly found in Stegocephalia, of which there is no trace in *Micropholis*.

The jugal is very small; it lies along the upper edge of the maxilla, and its anterior end is united by a suture to the lachrymal. Its slender posterior end just meets the anterior end of the post-orbital in the middle of the lower border of the orbit, the two bones being covered outside by the maxilla.

The post-orbital is a very large bone forming a great deal of the posterior and lower borders of the orbit, having a very extensive suture with the maxilla and also touching the jugal and quadrato-jugal.

4. In the temporal region the three bones squamosal, intertemporal, and supratemporal are present. The squamosal has its usual relations, the sub-otic part of the bone sheathing the back of the quadrate and meeting the pterygoid. The other two bones are not in relation to any underlying bones and are remarkable in that the posterior bone, the supratemporal, is much reduced, covering a very small area

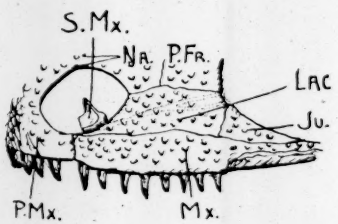


FIG. 2. *Micropholis Stowi*. Side of face. × 2. From a Geological Society specimen. The dotted lines in the lachrymal mark the course of the ductus naso-lachrymalis.

between the squamosal, intertemporal, and tabular. In every other Stegocephalian that I remember the intertemporal is the bone which is reduced, the supratemporal remaining large.

The palate (Text-fig. 3) is beautifully shown in Owen's type-specimen.

The basi-occipital has not been seen, but R. 510*a* shows well the two large exoccipital condyles, from above and the back. The basisphenoid is not well shown, but has large laterally directed basipterygoid processes with which the pterygoids articulate.

There is a large parasphenoid forming a plate much higher than wide, whose upper edge is channelled to receive the cartilaginous mesethmoid. The lower surface of the parasphenoid bears a double row of small backwardly directed sharp teeth.

The pterygoid articulates loosely with the basipterygoid process of the basisphenoid, sends a ramus, which consists of a deep narrow

plate whose upper border nearly touches the roof of the skull, back to cover the inner side of the quadrate, and to articulate with the squamosal.

The rest of the bone appears in the palate, and its lateral border has a suture with the palatine.

There is apparently no transpalatine. The palatine is an extremely narrow slip of bone lying between the maxilla and the very large interpterygoid vacuity. It apparently bears three rather large teeth. Its inner border is in contact with the pterygoid behind and the prevomer in front, and its anterior border forms the back of the posterior naris.

The prevomers are large bones meeting one another in the middle line, articulating in front with the premaxillæ and forming the inner borders of the posterior nares, each of which is enclosed by a row of teeth.

All the individuals have the lower jaw present and tightly closed on the skull. The jaw is very slender, and the thin bones of which

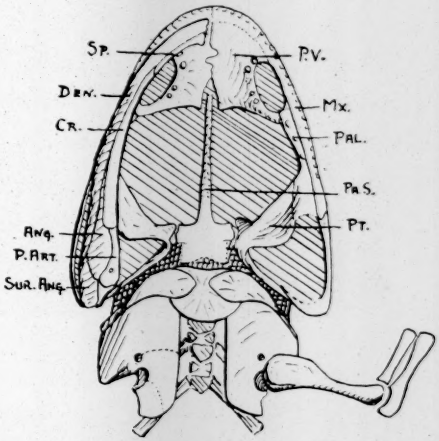


FIG. 3. *Micropholis Stowi*, Hux. Ventral surface of anterior part of skeleton. × 1. Skull from R. 510. Lower jaw from all material. Shoulder-girdle and vertebræ from a specimen in the Geological Society's Collection. *Ang.* angular; *Cr.* coronoid; *Den.* dentary; *P.Art.* prearticular; *P.v.* prevomer; *Pa.S.* parasphenoid; *Pal.* palatine; *Pt.* pterygoid; *Sp.* splenial; *Sur.Ang.* surangular.

it is composed have long overlaps: in development the ends of these bones are almost always pulled off with the matrix, but owing to the abundance of material it is possible to be quite certain of the structure.

The articular is well ossified, but not produced behind the articulation. Its inner side is covered by the prearticular, which extends forward below the supra-Meckelian vacuity on the inner side of the jaw for nearly half its length. In front its upper end rests against the dentary. The hinder end of the prearticular is pierced by a small foramen for the chorda tympani (seventh nerve). The outer

side of the articular is covered by the surangular, which reaches so low down that it very nearly, if not quite, touches the prearticular.

The angular is a boat-shaped bone forming the lower surface of the jaw and overlapping the surangular and prearticular.

The dentary is a long bone extending from the symphysis far back, overlapping the surangular and angular, and towards the front forming the lower edge of the jaw.

The coronoid is a very large bone on the inner side of the jaw, reaching well forward and running back with a long overlap on to the angular and prearticular; in all regions it comes right down to the lower edge of the jaw.

The splenial is a small bone on the inner side of the jaw, which has a symphysis with its fellow, and passes backward, overlapping the coronoid.

The material does not show whether an epicoronoid was present or not, but if present it must have been small.

Vertebral column. R. 510*a* has fourteen vertebræ in a continuous chain behind the skull, which are exposed from the dorsal surface. Another specimen shows the ventral surface. The atlas is shown in R. 510*a*. The neural arch is in two pieces which meet or nearly meet in the middle line. They are large and carry the facets for the exoccipital condyles. Behind and below is a small pleurocentrum,

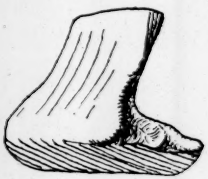


FIG. 4. Left scapulo-coracoid of *Micropholis*. × 1⅓. Geological Society specimen.

which articulates also with the neural arch of the second vertebra. The specimen cannot be cleaned sufficiently to show the intercentra in this region.

All the succeeding vertebræ are much alike; they are tripartite rachitomous vertebræ of very slender build.

The neural spines are of medium height and the zygapophyses slender and narrow from side to side. The anterior vertebræ have a strong transverse process carried on the pedicel; in succeeding vertebræ this becomes progressively shorter.

The pleurocentra are very thin plates of bone of which little can be said, and the intercentra are small wedge-shaped pieces of a cylinder bearing a special projection for the articulation of the rib.

The ribs are sufficiently described by Figs. 1 and 3, the more posterior ribs being similar but more slender.

The shoulder-girdle is very well shown in a specimen formerly belonging to the Geological Society. The cartilage bones of each side are fused into one mass in which the sutures shown dotted in Fig. 3 are only very doubtfully recognizable.

The scapula has a large thin blade quite smooth on the outer surface, and, if the sutures are correctly recognized, is turned inwards in front so as to form a horizontally placed sheet of bone on the ventral surface, which is continuous with the coracoid and precoracoid, which are wholly on the ventral surface of the animal. The scapula above the glenoid cavity is strengthened by the development of a strong buttress on its inner side near the posterior margin of the blade. This results in the formation of two deep pockets on the inner and posterior sides of the bone which are connected by the supra-glenoid foramen. There is also a 'coracoid' foramen in the suture between the scapula and the precoracoid. There is apparently no glenoid foramen. It is perhaps of interest that a glenoid foramen occurs in the majority of frogs, where I have observed it in the genera *Discoglossus*, *Alytes*, *Bufo*, *Megalophrys*, *Scaphiopus*, *Nototrema*, *Phyllomedusa*, *Hyla*, *Limnodynastes*, *Calyptocephalus*, *Leptodactylus*, *Ceratobatrachus*, *Rana*, *Breviceps*, *Callulops*, *Rhombophryne*, *Callula*, and *Cacopus*; it does not occur in *Pipa*, *Hymenochirus*, and *Xenopus*.

The interclavicle is a thin rounded plate of bone with no stem, and the clavicles are very slender, bent at right angles, and like the interclavicle scarcely at all ornamented. The cleithrum is not fully

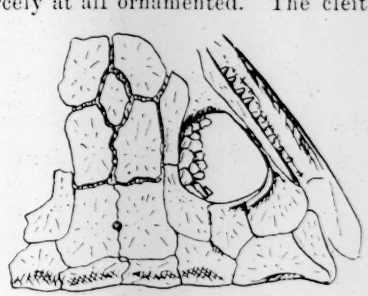


FIG. 5. Skull of ? *Ricnodon*, R. 2818. × 1. To show the interfrontal and the small dermal ossifications in the orbit.

exposed, but is, so far as seen, a very slender slip of bone lying along the front of the scapula; it seems to be certain that it was not continued up so as to form a cap over this bone, as in such types as *Eryops* and *Cacops*.

The humerus is a very remarkable bone; it has only slightly expanded ends, whose broad planes are at right angles to one another, and the deltoid crest is both slender and short. The radius and ulna are sufficiently described by the figures (Figs. 1, 3). The carpus is well ossified even in the young individual in which it is preserved, and the metacarpals and phalanges are little hour-glass shaped bones.

Dermal armour. No specimen, except Huxley's type, shows any of the scutes in position, but it is probable that the whole of the skin between the lower jaw and the clavicles was strengthened by a mosaic of small polygonal scales. I have seen no dermal ossifications behind the shoulder-girdle on either the dorsal or ventral surface.

One specimen shows a series of 'sclerotic' plates in the orbits; these are not well preserved, but seem to be restricted to the upper

part of that opening and to have united by their edges to the upper border formed by the pre- and post-frontals and frontal. Comparison with the very similar series of bones in the orbit of the specimen of ? *Ricnodon* (Fig. 5) shows that these bones are not really in the eye at all, but are dermal ossifications in the eyelid corresponding roughly to the palpebral bones of crocodiles.

Micropholis Stowi comes from the *Procolophon* beds, the age of which, although not accurately known, is undoubtedly either Lower or Middle Trias. It is hence of much interest as the latest rachitomous Stegocephalian, of which much is known (isolated vertebræ were described many years ago by v. Meyer from the Lettenkohle of Wurttemburg). It is an exceedingly advanced type, as is shown by the following features:—

1. The unique arrangement of the bones of the top of the skull.
2. The enormous interpterygoid vacuities. I showed recently that the really primitive Amphibia (*Pteroplax*, etc.) have very small interpterygoid vacuities, and that enlargement of them is one of the chief lines along which the characteristic Amphibian as opposed to reptilian evolution takes place. They are larger in *Micropholis* than in any other rachitomous type, but, as in all members of that order, the pterygoids are articulated with the basisphenoid and not suturally united with the parasphenoid as in all *Stereospondylus* types.
3. The slender clavicles and great reduction of the cleithra, a parallel specialization to that common to the Reptilia.
4. The very slender humerus.
5. The loss of the grooves for lateral line sense organs.

Despite its many advanced characters, *Micropholis* is a comparatively unspecialized animal, free from the many bizarre features of such types as *Trematops*, *Cacops*, and *Dissorophus*. Its ancestors are unknown, and no types really closely allied to it have been found, so that it will have to form a separate and distinct family.

III.—*Psalidocrinus*: a new genus of Crinoidea from the Tithonian of Stramberg.

By Dr. Mauric Remeš, Olomouc, Moravia, and Dr. F. A. Bather, F.R.S., British Museum (Nat. Hist.).

Papers referred to.

1891. Jaekel, O. "Ueber Holopocriniden, etc.": Zeitschr. Deutsch. geol. Gesell., vol. xliii, pp. 557–670, pls. xxiv–xliii.
1907. Jaekel, O. "Ueber die Körperform der Holopocriniten": N. Jahrb. f. Mineral., Festband, pp. 272–309.
1912. Remeš, M. "Nové zprávy o lilijicích z moravského tithonu": Zvláštní otisk z časopisu moravského musea zemského. Brno 1912. Ročník xii, čís. 1, pp. 157–169, pls. i–iii.

PART I. By Dr. M. Remeš.

THE species *Eugeniacrinites strambergensis* was described by me in 1912 (pp. 161, 167, pl. iii, fig. 2) on the evidence of a single specimen (A). Examination of a better specimen (B), subsequently acquired, and believed to be of the same species, has convinced me that, though the species appears to belong to the family Eugeniacrinidæ, Zittel, still it belongs to none of the known genera. This

new genus, it is true, resembles *Apsidocrinus* in the union of its interradial processes, which form a kind of vault above the patinal cavity (Jaekel, 1907, p. 304; Remeš, 1912, pp. 163, 168), but it differs from that genus in the form of the interradial processes, and especially in the size and shape of the radial facets.

Description of the Specimens.—(A) Holotype of *Eugeniacrinites strambergensis* (Text-figs. 6–8). The measurements of the patina are: height, *circa* 8 mm. [incomplete]; diameter at base, *circa* 5 mm.; diameter at upper margin, *circa* 12 mm. In the lower half the sides of the patina ascend almost vertically, but spread outwards rapidly in the upper half, till the level of the radial facets is reached. The interradial processes, of which two are partially preserved in this specimen, then ascend almost vertically, but with a slight inward bend, for a short distance. Their broken surfaces then bend rather sharply towards the oral pole, at the same time spreading out above the radial facets and then ending in a point, so that the outline of the whole cross-section somewhat resembles that of a spade in playing-cards (Text-fig. 6). The radial facets (Text-figs. 7, 8) are large and wide, with deep muscle-fossæ. In the upper part of the patina, wherever preserved, the interradial sutures are distinctly depressed. The patinal cavity is spacious. It was the resemblance of the patina and of the radial facets to those of *Eugeniacrinites* which caused me formerly to refer the specimen to that genus, and to compare it with *E. armatus*, Zittel, and *E. alpinus*, Ooster.

(B) Second specimen (Text-figs. 1–5). This also is a patina, and has the following measurements: height, from stem-facet to summit of interradial processes, 17 mm.; diameter at stem-facet, 4·8 mm.; diameter at level of radial facets, 16·4 mm. In external form this specimen resembles the holotype, except that the interradial processes are better preserved, one of them being almost complete. From this one we may infer that they were large and wide at their proximal ends, but thinner above. About the middle of their height they spread out on each side into a wing-like process. The interradial sutures are distinctly and deeply depressed, starting from about half-way up the patina. Radial facets (Text-figs. 3, 4) large, deeply notched; they stretch almost half-way up the interradial processes. On them may be observed a ligament surface, ligament fossa, axial canal, and the transversely elongate muscle-fossæ and articular fossæ.

In both specimens the external surface of the patina is smooth, with no distinct trace of any sculpture.

Diagnosis of Psalidocrinus (ψαλίς, ψαλίδος, a vaulted chamber; the name marks the resemblance to *Apsidocrinus*). — Patina resembling that of *Eugeniacrinites* in external form, with stem-facet sometimes excavate, sometimes level, having a star-shaped mark round the lumen; interradial processes well developed, coalescing in their upper part to form a vault over the patinal cavity, large at the bottom, tapering towards the top, marked externally in their lower part by deeply depressed interradial sutures; radial facets large, reaching half-way up the interradial processes.

Genotype.—The evidence for this genus is presented by specimen B, which I believe to belong to *Eugeniacrinites strambergensis*. But

should specimen B ultimately be placed in a different species, then the species to which it is referred will be the genotype of *Psalidocrinus*.

From *Apsidocrinus* this genus differs chiefly in its large radial facets and in the different shape of the interradial processes. In my opinion it has been modified from *Eugeniacrinites* in the same way as *Apsidocrinus* has been modified from *Phyllocrinus*. This seems to be proved, not only by its external form and its flattened but spacious patinal cavity, but especially by the larger size and peculiar shape of the radial facets, which, as in *Eugeniacrinites*, reach far up the interradial processes.

It seems probable that the brachials of this crinoid resemble those of *Eugeniacrinites* in shape. I am, however, not convinced that the brachials described by Jaekel as axillaria of *Eugeniacrinites* really belong to that genus. On the contrary, I am inclined to ascribe to both *Eugeniacrinites* and *Psalidocrinus* such axillaria as resemble *Cyrtocrinus* in their articular surfaces. Among the isolated brachials as yet discovered, however, I am not able to identify any with those of *Psalidocrinus*.

Both the specimens herein described are in my collection, and were obtained from the marl layers of the white limestone quarry, "Obecní lom," in Stramberg, Moravia.

PART II. By F. A. Bather.

(Published by permission of the Trustees of the British Museum.)

Dr. Remeš, having paid me the compliment of entrusting me with the editing of his manuscript and with the preparation of the illustrations to his paper, has also been good enough to permit me to develop his specimens more than was possible for him. Although this led me to communicate to him certain criticisms, it seemed inadvisable to modify his manuscript to any great extent. Except, therefore, for a few measurements which I have taken the liberty of rendering more precise, Dr. Remeš remains responsible for the contents of his own paper.

The fixing on specimen B as the type of the new genus was due to my suggestion, and the present note is intended to show why that course seemed to me particularly desirable. In a word, I cannot readily agree with Dr. Remeš that his specimens A and B belong to one and the same species. The differences are as follows:—

The stem-facet in A is, as Dr. Remeš recognizes, markedly hollowed; in B it is flat. In A the ratio of the stem-facet to the greatest diameter of the patina is ·37; in B it is ·29. In A the outline of the facet is subpentagonal with rounded radial angles; in B it is subcircular. In neither specimen can I detect the "star-shaped mark round the lumen", but in B the joint-face is covered with irregular, anastomosing, rather obscure pustules, with a slightly radiating arrangement (Text-fig. 2); in A there are only some obscure depressions in the cavity, apparently interradial in position, but that is rather vague. It may be noted, by the way, that the plane of the stem-facet in B is a little oblique to the main axis (Text-fig. 1).

The lower half of the patina of A was described by Dr. Remeš (1912, p. 167) as 'cylindrisch', a phrase that he has permitted me to modify in his present description. Even this, however, does not go far enough to justify the statement that B resembles A "in external form". So far as measurements are at all possible, the actual facts are these: in the lower part of the patina the sides approach at an angle of 45° in A, of 80° in B; in the upper half of the patina the sides approach at an angle of 105° in A, of 108° in B. Therefore the lower part meets the upper part at an angle of 145° in A, of 166° in B.

The view of the patina from below (Text-fig. 2, and Remeš, 1912, pl. iii, fig. 2*c*) shows a clear difference of surface-modelling. In A the interradial depressions continue from the margin of the patina to the stem-facet; in B they continue only half-way, and each is then succeeded by a distinct interradial swelling.

The interradial sutures can be distinguished in A, but are by no means to be made out in B.

The view of the patina from above (Remeš, 1912, pl. iii, fig. 2*b*) shows in A a patinal cavity, which Dr. Remeš rightly describes as spacious. He was unable to see the cavity in B, but I have convinced myself that it was far more restricted. A proof of this is given by the next observation.

A cross-section of an interradial process, just above the level of the radial facet, is given for A (Text-fig. 6) and B (Text-fig. 5). The difference of form, though not great, is sufficiently obvious. The difference of relative size is even more marked; in A the ratio of the interradial diameter of the process to the total diameter of the patina is ·33; in B the same ratio is ·43. This means that the diameter of the patinal cavity is less in B by 20 per cent.

The radial facets are described by Dr. Remeš as though they were precisely similar in the two specimens. They have, no doubt, the same general character, which, as he justly points out, approaches that of *Eugeniacrinus* rather than of *Phyllocrinus* and *Apsidocrinus*; but the differences between them are fairly striking. In A (Text-fig. 7) the radial groove proper is short and small, and little more than a tongue-like depression at the bottom of the wide V formed by the sloping upper borders of the muscle-plates; in B (Text-fig. 3) it is a deep U, of which the sides ascend almost vertically and meet the corresponding upper borders of the muscle-plates at an angle which approaches a right angle. The same difference finds expression in the far greater height of the muscle-plates in B than in A, and this height is due to an enlargement of the tract above the wide and deep muscle-fossæ. This tract bears the articular depressions which Dr. Jaekel (1891, p. 641, text-fig. 20) has named "Gelenkgruben", and has also shown clearly in his restorations of *Eugeniacrinus caryophyllatus* (1907, pp. 300, 301, text-figs. 21, 24). In A those depressions are almost imperceptible; in B they not only occupy a larger field (as just explained), but seem, from the evidence of the better preserved among the facets, to have been fairly pronounced. The difference between the muscle-plates of the two specimens is also apparent when the radial facets are viewed from above; in A (Text-fig. 8) the upper part of the muscle-plate projects right

over the muscle-fossa, so as almost to cover the ridge which separates this fossa from that for the interarticular ligament; in B (Text-fig. 4) the whole plate slopes more inwards, so that this ridge is clearly exposed and the muscle-fossa itself is partly visible.

It follows from the differences in the radial facets that there was a corresponding difference in the arms.

From the differences in the patinal cavity and the relations of the interradial processes, so far as they are preserved, one may also infer that there was some difference in the portions of the interradial processes not preserved in A. Whether this difference was so great that the processes did not meet over the oral centre as they do in B and in *Apsidocrinus*, one cannot say. Dr. Remeš believes that they did so meet. In either case the large size of the interradial processes in A indicates an approach to the apsidal or psalidal character, and so far justifies Dr. Remeš in his removal of the specimen from *Eugeniacrinus*.

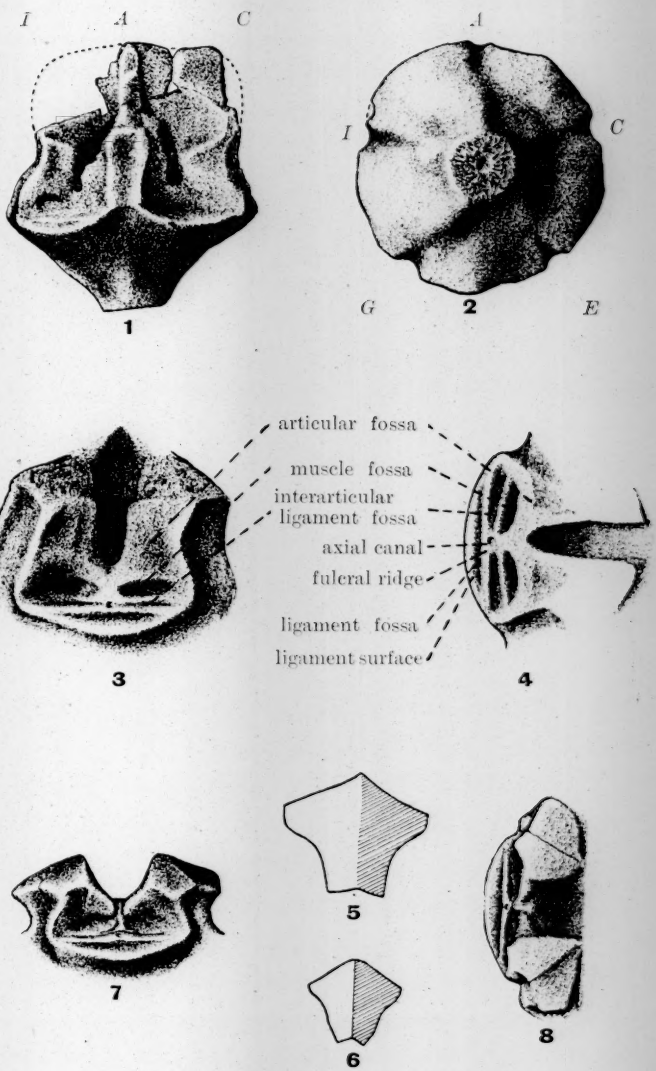
Time and opportunity do not permit me at present to make a thorough study of the numerous genera that have been established in the Eugeniacrinidæ since I last attacked the subject. Dr. Remeš believes that *Psalidocrinus* is a homœomorph of *Apsidocrinus*, having been modified from *Eugeniacrinus* in the same way as *Apsidocrinus* was modified from *Phyllocrinus*. But while it is fairly safe to associate *Apsidocrinus* with *Phyllocrinus*, it is by no means clear that *Psalidocrinus* is so intimately connected with *Eugeniacrinus*. The Eugeniacrinidæ, as restricted by Jaekel (1907), are distinguished *inter alia* by the very small size of their interradial processes and the correspondingly peculiar development of their primaxils, which can meet centrally over the patinal cavity. This line of development is the converse of that followed by the Phyllocrinidæ (Jaekel, 1907), in which the interradial processes are large and may meet centrally, while the primaxils are unspecialized. Therefore *Psalidocrinus* cannot well be derived from a Eugeniacrinid in Jaekel's sense. On the other hand, the large size of the radial facets justifies the contention of Dr. Remeš that *Psalidocrinus* is not a descendant of *Phyllocrinus*. We must therefore seek for an ancestor among more primitive Holopodidæ, such as *Sclerocrinus* and *Cyrtocrinus*.

Provisionally, at any rate, *Psalidocrinus* is to be accepted. But the principles governing our acceptance themselves render it difficult to place the genus in any one of the families as defined by Jaekel (1907). Logically, one ought to erect a new family for it, but until further evidence is forthcoming it is preferable to call it merely a Eugeniacrinid *sensu lato*.

It is, however, necessary to distinguish specimen B from specimen A. The latter is the holotype of *Eugeniacrinus strambergensis*, Remeš. Therefore I make B the holotype of a new species, *Psalidocrinus remeši*; and, in accordance with the express instructions of Dr. Remeš, that species is to be regarded as the genotype of *Psalidocrinus*. The conclusions of this note are summarized in the following diagnoses:—

Psalidocrinus, Remeš.

A Eugeniacrinid with interradial processes stout and elevated so as to coalesce centrally over the patinal cavity. Radial facets wide,



PSALIDOCRINUS.

FIGS. 1–5. *Psalidocrinus remeši.*
,, 6–8. *Psalidocrinus strambergensis.*
FIGS. 1, 2, × $\frac{2}{1}$. FIGS. 3–8, × $\frac{3}{1}$.

swimming-feet (doubtless also branchigerous); the body is terminated by a pointed telson or tail-spine, giving origin to a pair of shorter lateral lamellæ from its base.

I have no hesitation in referring this unique specimen to the Branchiopoda.

In Sir Ray Lankester's Treatise on Zoology, 1909, ch. ii, p. 29, Dr. W. T. Calman, writing on the Crustacea, divides the sub-class Branchiopoda as follows:—

Order 1. Anostraca—*Branchinecta*, *Artemia*, *Chirocephalus*, etc.
,, 2. Notostraca—*Lepidurus*, *Apus*, etc.
,, 3. Conchostraca—*Estheria*, etc.
,, 4. Cladocera—*Daphnia*, etc.

Sub-order 1. Calyptomera (tribe 1, Ctenopoda; tribe 2, Anomopoda).
,, ,, 2. Gymnomera (tribe 1, Onychopoda; tribe 2, Haplopoda).

In this sub-class the carapace may form a dorsal shield, as in *Apus*, *Lepidurus*, etc. (the Notostraca); or a bivalved shell, as in *Estheria*, etc. (the Conchostraca); or it may be entirely absent, as in the specimen before us and in *Artemia*, *Chirocephalus*, *Brachinecta*, etc. (the Anostraca).

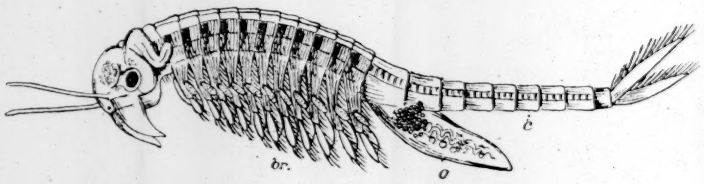


Fig. 1. *Chirocephalus diaphanus* (living freshwater). Enlarged three times nat. size. These animals always swim upon their backs. Reproduced (reduced) from Baird's *Nat. Hist. British Entomostraca*, 1850.

The range in time of the sub-class Branchiopoda is very great. Professor C. D. Walcott has figured an *Apus*-like form of Crustacean, *Protocaris Marshii*, in his "Fauna of the Lower Cambrian, or *Olenellus* zone" (Tenth Ann. Rep. U.S. Geol. Surv., pl. lxxxi, fig. 6). Professor T. Rupert Jones has figured *Estheria membranacea* (Pacht) (Pal. Soc. Foss. *Estheriæ*, 1862, p. 14, pl. i, figs. 1–7) from the Old Red (Devonian) of Caithness. Dr. Friedrich Goldenberg, in his *Fauna Saræpontana Fossilis*, 1873 ("Die Fossilen Thiere aus der Steinkohlenformation von Saarbrücken"), described and figured (Heft i, p. 23, Taf. i, fig. 15) six somewhat doubtful-looking segments which he attributes to *Branchipus*, and names *Branchipusites anthracinus*. The following is a translation from Dr. Goldenberg's paper:—

Of this animal eight segments are to be seen in profile; but of these, the first and last are very imperfect. The middle segments are also imperfectly preserved, so that one can only find indications of their segmentation. The lateral appendages (side-pieces or epimera), of which six are present, are pretty perfect in their natural connexion, and have much resemblance to the lamellar branchial feet of a *Branchipus*. Their anterior margin is somewhat incurved;

the hinder margin, which is parallel to the anterior, bends at about two-thirds of its length at an obtuse angle towards the apex of the anterior margin. In the middle of this oblique-inferior margin oval thickenings make their appearance, which I regard as remains of branchiæ which were attached here to the base of the lobe of the unjointed swimming-feet. The substance of these swimming-feet seems to have been membranous and of a blackish-brown colour.

This is the only record of a Palæozoic form of supposed Anostracan Branchiopod that I have met with.

I have, however, described an undoubted species referable to this division of the Branchiopoda (the Anostraca) from the Eocene (Bembridge) freshwater limestone of Gurnet Bay, Isle of Wight, which I named *Branchipodites vectensis* (see Quart. Journ. Geol. Soc., May, 1879, vol. xxxv, pp. 345–6, pl. xiv, figs. 6–10). It is interesting to mention that in this case both the males with their large clasping antennæ, and the females with small antennæ and egg-pouches, with large and very distinct disk-like bodies (the compressed eggs), can be seen distinctly in numbers upon the slabs of limestone from Gurnet Bay.

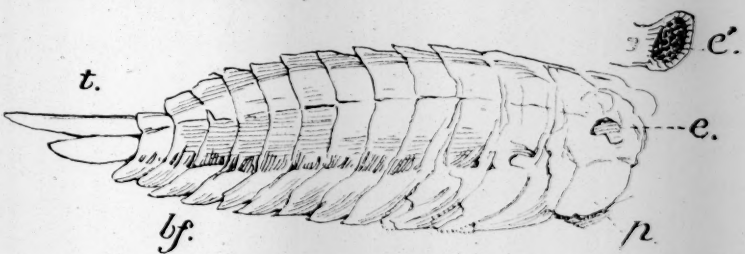


FIG. 2. *Rochdalia Parkeri*, H. Woodw., gen. et sp. nov. Middle Coal-measures: Sparth, Rochdale, Lancs. Enlarged three times nat. size. *t.* telson; *bf.* branchial feet; *p.* proboscis; *e.* position of eye; *é.* diagram of pedunculated eye (restored).

Description of the Rochdale specimen (Fig. 2).—The head, which is rounded in outline anteriorly, is 5 mm. in breadth and 9 mm. in depth, its widest part being the broadly expanded downward extension of the beak-like proboscis (*p.*).[1] The position of the eye (*e.*), which was no doubt pedunculated, as in the living examples of the Anostraca, is marked by the broken base of the peduncle; a suggested restoration of the eye (*é.*) is given separately above the head.

The four body-segments following behind the head are the largest, being equal in breadth to the seven succeeding segments, and they have also the longest recurved lobe-like swimming-feet (*bf.*); the seven hinder segments gradually diminish in depth backwards from 10 mm. to 5 mm. The segments are marked by a minute line, probably indicating the points of attachment of the branchial lobe to each of the swimming-feet; there is also a median dorsal line marked by a minute but distinct ridge, indicating the articulation of the body-segments to each other. The telson (*t.*) is 7 mm. in

[1] The proboscis is probably too small to indicate a male, but there is no trace of an egg-pouch to definitely fix the specimen as a female.

length, and is narrow and pointed, and its lateral lamella is rounder, shorter, and broader, being 4 mm. in length. The elongated posterior part of the trunk, which is without limbs, and which in *Chirocephalus* and *Branchinecta* makes up half the length of the animal, and consists of from seven to eight rounded segments destitute of limbs, is not developed in the Rochdale specimen; but in all the Branchiopoda the number of trunk-somites varies greatly (from eleven to nineteen in the Anostraca), whilst in the larval stages the number of segments is often much fewer than in the adult, especially as regards the apodal caudal segments. I think there is but little doubt that this specimen represents a mature individual, but bearing in mind the fact that it is of so great a geological age as the Coal-measures, one would not be surprised to find that it may have retained to some extent the larval characters of the family in its adult condition; the development of the caudal segments in later geological times may probably be the outcome of a more active lacustrine or pelagic life pursued by its descendants, and continued down to the present day.

The entire absence of a carapace, the form of the head, the probable presence of pedunculated eyes, and the general arrangement of the body with its branchigerous swimming-limbs, lead me to consider that its appropriate zoological place is with the Branchiopoda, and in the order Anostraca.

It may be convenient to suggest a new genus for its reception, and I would venture to propose the generic appellation of *Rochdalia* as a record of the locality which has yielded so remarkable and so rich a fauna; and *Parkeri* for the specific name, after its discoverer, who is one of the most enthusiastic of local collectors, and has added so largely to our knowledge of the Carboniferous Invertebrata of Lancashire.

V.—Notes on the Cretaceous Formation of Bahia, Brazil.

By Joseph Mawson, F.G.S.

(WITH A SKETCH-MAP.)

THE Cretaceous formation of Bahia, first brought prominently to notice by the discoveries of Allport[1] in 1859, has been in great part examined and described by the late Professor Hartt,[2] by Dr. O. A. Derby,[3] by Dr. R. Rathbun,[4] and by Dr. J. C. Branner.[5] Some additional observations made by the present writer were published in the Geological Society's Journal of May, 1907, to accompany Dr. A. Smith Woodward's paper on the Vertebrate Fossils of the formation.

[1] S. Allport, Quart. Journ. Geol. Soc., vol. xvi, p. 263, 1860.

[2] C. F. Hartt, *Geology and Physical Geography of Brazil*, 1870.

[3] O. A. Derby, "A Bacia Cretacea da Bahia": Archivos do Museo Nacional, Rio de Janeiro, vol. iii, p. 135, 1878.

[4] R. Rathbun, "Observações sobre a Geologia. Aspecto da Ilha de Itaparica": ibid., p. 159.

[5] J. C. Branner, "The Stone Reefs of Brazil": Bull. Mus. Comp. Zool. Harvard Coll., Geological Series, vol. vii, p. 150, May, 1904.

The Map now given (p. 360) shows the Cretaceous formation along the coast of the bay from Montserrat as far as Toque Toque, i.e. the district adjacent to the city of Bahia, and it is offered, with a few further notes, as an aid to any observer who may have opportunity and inclination to take up work which the writer has now had to relinquish.

Association of Fossil Mollusca with Fossil Vertebrate Remains.

Amongst other instances noted are the following:—

Towards the Montserrat end of Pedra Furada Bay three parallel bands of limestone stand out distinctly in the cliff and on the beach. Scales, teeth, and bones of fishes associated with shells of the univalves common to the other beds of this series are found encrusted in places in these bands. The shale between them contains *Estheria*, etc.

Immediately underlying the lowest of these limestones is a thick bed of dark-blue shale, which also contains scales (of two or more species of *Lepidotus*) and other fish-remains associated with molluscs (*Anodonta*, *Paludina*, *Melania*, etc.). This same shale has also yielded a tooth of a Pterosaur, and contains a fine-textured thin greenish layer, with a lustrous surface showing numerous small delicate bones, with shells of molluscs and Ostracods.

In a thin bed of shaly sandstone, a little nearer than the above to Pedra Furada, all the smaller shells are found in abundance, and with them I have discovered small scales and teeth of *Lepidotus*, etc.

Between Pedra Furada and Bomfim a blue shaly mudstone has yielded a portion of a large scale of *Lepidotus*, associated with shells (not specified). A limestone near here full of shells (*Melania*, etc.) has yielded fragments of bone or teeth. A long slender species of *Melania* appears to be new and undescribed.

A little above km. 4, Bahia and San Francisco Railway, in an inlet of the bay, *Estheriæ* and Cyprids are found in a bed of shale with *Megalurus* and other fish-remains.

At km. 7½, on the beach, in a blue shale under conglomerate, a small *Planorbis* is found amongst an abundance of Entomostraca, and this shale contains also teeth of crocodile and a variety of scales, bones, and teeth of fishes, etc.

At Setúbal the interstratified gravels and mudstones contain various teeth, large and small, of reptiles and fishes; scales, etc., of fishes; and with them I have observed a mollusc (*Paludina*).

Km. 78–82. Cuttings on the railway line here show a soft yellow shale, bearing shells and a few fish-remains. The shells agree with those from San Thiago.

Km. 86, San Thiago. Over a tough drab-coloured shale, nearly unfossiliferous, lies a softer mellower shale containing *Anodonta* and other shells, and immediately overlying this is a bone-bed crowded with vertebrate remains.

At Ponto de Matuim, across the bay by canoe from Mapelle station (km. 22), there is a hard grey stone in reefs, with fossil remains of fishes and Entomostraca in various beds.

On the beach beyond Toque Toque is a highly fossiliferous rock (which may be compared with that of Mapelle Quarry), composed of

angular fragments of stone in a hard matrix; it contains scales of *Lepidotus*, teeth and other remains of reptiles and fishes, shells of *Paludina*, and *Melania* of two species or varieties (one long and slender, probably not yet described). The shells are often finely weathered out in cavities of the stone.

Raised Beach near Toque Toque.

This recent raised beach, discovered by the writer in 1880, is well described and figured in Dr. J. C. Branner's work, p. 150, and is referred to here on account of the shells with coral of which one stratum is mainly composed. A few specimens of these are in the British Museum (Nat. Hist.), but more should be obtained, as they would probably indicate the period of the latest upheaval of the coast on the bay.

It will be seen by the map that this raised beach appears at intervals nearly as far as Plataforma station, following the sinuosities of the present coastline.

Beach, Bomfim to Pedra Furada.

The Cretaceous cliff between these two points was thought to be barren of vertebrate remains, but shortly before the writer left Brazil a thin layer rising from the beach was found to be rich in fossil fishes of various species in an extremely fine state of preservation.

There seems to be no reason why other layers should not be fossil-bearing, and the locality requires to be more fully explored; but care is necessary in wet weather, when falls from above are likely to occur.

Mapelle Quarry near north end of Tunnel.

The highly fossiliferous beds exposed in this now disused quarry were first made known by Dr. O. A. Derby, and are fully described in his "A Bacia Cretacea da Bahia" (1878). I have nothing to add, except that the top soil has been (I believe since he wrote) to a large extent removed, laying bare the petrified bed of what in Cretaceous times must have been a running stream, with the groovings, ripple-marks, and half-embedded pebbles standing out in sharp relief, thus confirming Derby's suggestion as to the origin of these deposits.

Plataforma to Itacaranha.

Portions of the blue shale on the beach here are often removed by the south-westerly gales in the winter months, April to June, laying bare a thin layer of a greenish hue, which is more than usually rich in fossil remains.

Here, as well as at Pedra Furada, concretionary limestone nodules are found in the shale. A sharp blow will occasionally disclose fishes or other remains in a fine state of preservation. Boulders of this limestone exhibit fossil bones, etc., but they are very difficult of extraction owing to the close texture and hardness of the stone.

A blackish shale met with on the Plataforma beach seems to be almost barren of remains.

Reappearance of Strata.

The formation at Setúbal, consisting of pebbly shale, sandstone, and loosely compacted gravel, rolled or gritty, intermixed with layers of yellow and blue mudstone, is exactly reproduced about 2 miles further along the beach at the last headland before San Thomé de Paripe, and in both places is fossiliferous, containing crocodilian and other teeth, scales of fishes, etc. There is a considerable resemblance to these in the beds under the fort at Montserrat, and again in those between Plataforma station and the viaduct, which are likewise fossil-bearing.

Tertiary Sandstone.[1]

Boulders of this coarse gritty brown sandstone are found also on the *taboleiros* on the Timbó Railway, beyond Alagoinhas as far as km. 33. The writer has examined many hundred blocks of this stone at Sitio Novo and other localities, but has failed to find any trace of fossils except, on one occasion, what appeared to be the impression of a reed or other coarse plant. Some of these boulders have smooth cylindrical holes an inch or more in diameter and a foot or more in depth, which generally occur singly. Their origin is unknown.

Periperi Tunnel, north end. Km. 11–12.

A black modern sandy soil, full of shells of molluscs, about 15 feet above the present beach, calls to mind an apparently similar formation in the island of Itaparica described by Mr. Rathbun; and in view of the interesting particulars given by him it is probable that the Periperi bed would repay the labour of a closer examination. Some of the shells are in the British Museum (Nat. Hist.).

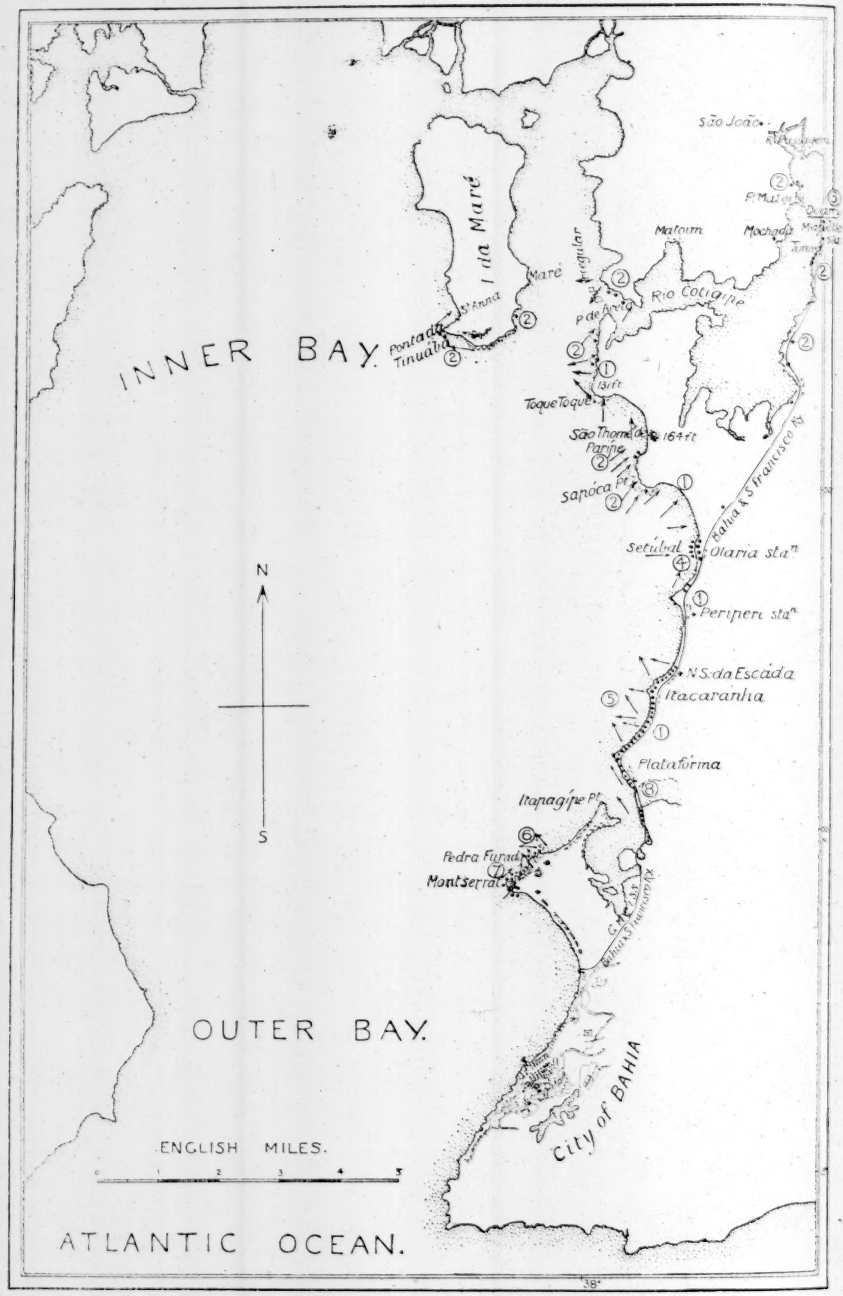
Cretaceous or Tertiary.

Above Agua Comprida station, km. 30 to 69 (Matta S. João), the formations met with on the line are, in general, Tertiary or Post-Tertiary, as described by Hartt; but the following occurrence appears to be doubtful: Above Camassari, at km. 50, a cutting shows a heavy bed of decomposing conglomerate, resting apparently on a kaolin-like clay, and from this place to km. 59 there are various exposures of the same decomposing conglomerate, overlying compact, sometimes clayey sands, purple, yellow, and pink, with a north-west or west dip. Above km. 60, beyond Feira Velha, there is a remarkably clear outcrop, about 20 feet high, of these variegated friable sands in well-defined parallel layers of from 6 or 8 inches to 3 feet, in the following order—

Bright warm yellow sand.
Purplish clayey sand.
Cool yellow sand.
Dark-pink (thin) muddy sand.
Reddish sand.
Yellow sand.

These bands have a very clear strong dip west to north-west. If more recent than Cretaceous, they seem to be worth describing on that account. I have not found fossils in any of the strata or in the

[1] See Hartt, op. cit., p. 367.



Map of the Coast around Bahia Bay, Brazil.
The localities referred to in Mr. Mawson's paper are all numbered on the map.

conglomerate, but, for want of opportunity, they have not been closely examined.

Pitanga Station Cutting.

This cutting is figured and described in Hartt's *Geology and Physical Geography of Brazil*, p. 368. The pink and white shale marked *g* has been found to contain several species of molluscs, some of which have not yet been found elsewhere. Specimens of these, not well preserved, are in the British Museum (Nat. Hist.), South Kensington. These strata are well worthy of further exploration. The contour of the cutting has been altered in late years.

EXPLANATION OF SKETCH-MAP (p. 360).

⟶ Indicating direction of dip of Cretaceous rocks as seen on the coast.

1. Exposures of recent Raised Beach.
2. Remains of reptiles and fishes, usually associated with Entomostraca and molluscan shells.
3. Quarry with numerous reptilian remains and fish-scales.
4. At Setúbal Point teeth of crocodiles are numerous, with small teeth and scales of fishes, and *Paludina*.
5. In the shales, limestones, and conglomerates between Escada and Plataforma numerous remains of reptiles (Crocodilia, Dinosauria, and Plesiosauria) and fishes (*Mawsonia*, *Lepidotus*, *Belonostomus*, *Diplomystus*, *Chiromystus*, *Acrodus*), with numerous molluscan shells and badly preserved Entomostraca.
6. In a high cliff a rich bone-bed with well-preserved fish-remains.
7. In the shales and limestones between Pedra Furada and Montserrat numerous remains of reptiles and fishes associated with molluscan shells and Entomostraca. A Pterosaurian tooth found here. Remains of reptiles and fishes also in the conglomerate at Montserrat.
8. In an inlet at km. 4, shale with Entomostraca and fish-remains (*Megalurus*, etc.) was met with.

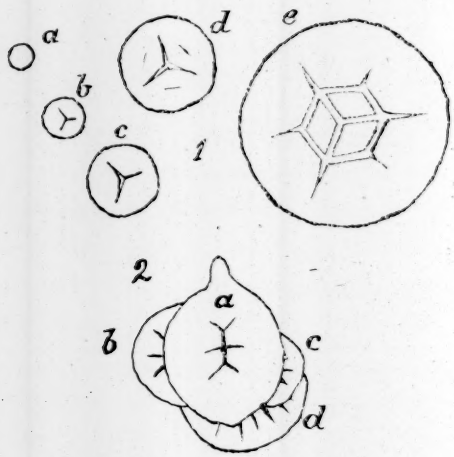
VI.—More about Septarian Structure.

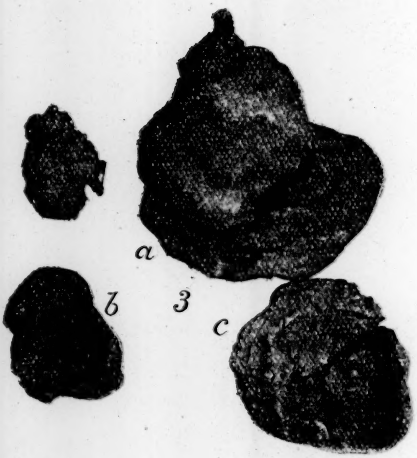
By J. E. Todd, M.A., Assistant Professor of Geology and Mineralogy, University of Kansas.

In his article on septarian structure in the March number of the Geological Magazine Dr. A. Morley Davies seems to call for further light upon the subject, hence the following is offered. The writer became convinced of the fallacy of the current teaching concerning the formation of concretions with cracked interiors and of septaria more than thirty years ago, and has so taught in his classes ever since. In 1902 he published a paper on "Concretions and their Geological Effects",[1] which presented facts which virtually demonstrate that the cracking is due to the expansion of the exterior rather than by a contraction of the interior, as Dr. Davies has also concluded.

The clearest evidence was obtained from compound concretions in the loess of Eastern Nebraska, of which illustrations are given. Simple concretions abound there, and uniformly whenever they are over an inch or two in diameter they are cracked inside. From them there is little instruction on the point under discussion except that the interior is of the same composition as the exterior, viz. fine silt cemented with carbonate of lime. There is not more of clay in the

[1] Bull. Geol. Soc. Am., vol. xiv, pp. 353 ff.





FIGS. 1*a–e*. A series of drawings illustrating the growth of a concretion having cracked interior, caused by the expansion of the exterior by more rapid interstitial deposition in that portion.

FIG. 2. Diagram of a compound calcareous concretion from the Loess of Eastern Nebraska. The different members were doubtless added in the order indicated (*a–d*).

FIGS. 3*a–c*. Photographs of fragment of such a concretion.

cracked portion, as the old theory postulated. The compound ones, on the contrary, are very instructive. They show apparently successive additions made on one side after another and sometimes one overlapping another, as in Figs. 2 and 3. To explain them by shrinking we must assume that small bodies of very contractile material had been mixed with less contractile in curious lenticular shapes by some inexplicable process. And if that be admitted, the cracks should be widest in the centres of the respective contractile members, whereas the facts are that the widest part of each crack is toward the centre of the whole. And the centre of the concave or inner side of each addition is evidently lifted away from the one under it.

By a further study of Figs. 2 and 3 it will appear very clearly that the most obvious and easy explanation is that there is first a collection of molecules of calcium carbonate in the pores of the silt around some nucleus, but the conditions are such that the deposition is not entirely at the surface, but largely in a shell reaching to a considerable distance below the surface. After the concretion has attained a certain size the centre will cease to receive additions to its mass, while the outer shell will continue growing both radially and tangentially, with force not only sufficient to crowd back surrounding and superincumbent material, but to also rend asunder the interior.

Should this seem incredible, let us remember the power of molecular attraction manifest in the tensile strength of wire, or in the supporting strength of rock, or of steel. In all cases it is the attraction of molecule for molecule, the apparently opposite directions in which it is manifested being due to different mechanical relations. The power of freezing water and the capillary action of water in wood which was used by the ancients for splitting rock are also illustrations of similar forces.

It may be noted further that the first cracking of the interior takes place when the thickness of the growing shell is several times the diameter of the ruptured interior, and that the cracks spread gradually toward the surface which they may eventually reach. When that is attained, water charged with various minerals will enter and begin filling the crevice. When lined with crystals they constitute a form of geode; when perfectly filled with crystalline matter, a true septarian.

Professor N. S. Shaler appealed to similar action in the formation of geodes of the common form, and also ascribed the filling of many veins to the expanding effect of crystallizing minerals.[1]

Dr. Davies argues in his paper that we should not hope to find effects of the expansion of the concretions in the surrounding shale because the compression of the shale was subsequent to the growth of the concretion. That may be true in some cases, but the writer has frequently noted in the shaly clays of the Pierre formation in South Dakota a shell of cone-in-cone structure surrounding large concretions of the sort under discussion. He has considered this a direct effect of the growth of the concretions.

[1] "Formation of Dikes and Veins": Bull. Geol. Soc. Am., vol. x, pp. 253 ff.

This expansive power of crystallizing or solidifying minerals may be credited also with the formation of those problematic structures known as 'stylolites' or 'lignilites'.

Given a horizontal film of some impervious substance in a mass of calcareous mud, hard particles above or below it to serve as nuclei for the deposition of calcareous material from one side only, and we should expect that this force of expansion in solidification would force a nucleus below the film upward and one above the film downward, simulating exactly what we find in 'stylolites'.

In closing, the writer would allude to another observation which seems to point in the same direction. He has often received drillings from artesian wells. When they have been put wet into glass bottles he has frequently found some of the bottles broken in drying. So far as tests were made, all those broken were found to contain matter highly calcareous, while those unbroken were sand or clay without calcareous material.

VII.—Geological Notes on a Human Skeleton found in Silt at Savonas, British Columbia.

By Geoffrey F. Monckton.

In the early part of 1910 I noticed some bones projecting from a cliff near the foot of Kamloops Lake, B.C. The cliff is composed of silt, and belongs to the formation known as the White Silts. These belong to the Quaternary period, having been laid down during the retreat of the great glacier. They stand in very steep banks, which is partly due to the small rainfall, only 7 inches, in this district. Little streams of water from melting snow, collecting in a hollow on the flat behind, had been for three years or so gradually cutting a fissure, and it was in the side of this fissure that these bones appeared. Some cutting down of the face of the cliff to bank up the trail exposed them more, and at the end of the year a road was made up it and we took them out. The silt is very definitely laminated. There are also a few seams of fine pebbles through it. One of these actually touched the bones. None of these seams or laminations showed any sign of movement of the ground. Had the bones been put in from the top it would have necessitated a hole 12 feet deep. A fissure would have left its mark on the seams of pebbles. People have been living along the beach in front of the cliff since 1860, and at that time the face of the cliff must have been at least 8 feet farther forward, as it has not only been constantly cut back from time to time in order to bank up the trail, but a good deal was taken away in the early eighties to level sites for houses. The bones must therefore be of the same age as the silt.

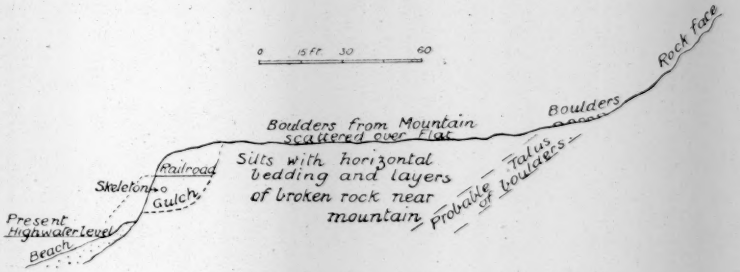
The silt is very dry, and contains a small quantity of lime. It should therefore be a good preservative medium.

As to its position, the bones of the body were all bunched together, the legs stretched forward, and the skull close to the knee, as if the body had rested in the soft mud in a sitting position, and, as it decayed, the bones had fallen together. I should imagine that its owner was drowned very likely by falling through thin ice. There

were no implements whatever found with the skeleton. Unfortunately the lower jaw is missing, but most of the other parts of the skeleton were found. A careful search revealed no teeth. During the following summer the Canadian Northern Railway laid a track across the spot in my absence.

I submitted this skeleton to Mr. Charles Hill Tout, who is well known for his ethnological work in connection with the British Association and who has made a special study of prehistoric man in British Columbia, and I quote from him as follows: "It was the skull of a mature person. All the sutures had coalesced. The type is also markedly dolichocephalic, the cephalic index being about seventy-five. In stature the individual was short, not much over 5 feet, and the ridges on the tibia or shin-bones are less sharp than those of modern man."

The bones are now in the hands of the specialist attached to the Canadian Geological Survey for examination. The exact point of discovery was about three hundred yards above the Thompson River Bridge, at the foot at Kamloops Lake, on the north side. It is about a mile from Savone station on the C.P. Railway.



Section showing position of skeleton in silts at Savonas, British Columbia.

Briefly, the later geological history of this district is as follows. During the Glacial period, the elevation was much greater than it is now. At the end of that period, the land gradually subsided as the ice receded. Dr. G. M. Dawson seems to think that it subsided to a depth of 4,000 feet below the present level, but I venture to differ as to that, and consider that 1,000 feet would be quite sufficient. After that it was again uplifted to its present position. Many large glaciers still remain in the country, and anyone who has travelled much in the higher mountains will realize that a greater snowfall or uplifting of the land would cause a great extension of the glaciers. A very complete description of the White Silts is given by Dr. G. M. Dawson, who named them, in vol. vii of the Canadian Geological Survey Reports. From this I quote: "It is probable that we may place the upper level of the Silt formation in this region at about 2,500 feet, though it is still apparent that the more important developments of the deposit lie below 1,700 feet. The Silt deposits are found in this part of the interior plateau down to

less than 1,000 feet, but it is possible that some of the lower-level deposits have been secondarily formed from the denudation of the higher.

"In the valley of the South Thompson the Silt formation is most characteristically represented, forming, as before stated, broad terraces or benches along the sides of the valley, with the surfaces gently sloping towards its axis, where the river has formed for itself a deep subsidiary channel. In some places, as above Kamloops on the south side of the valley, the edge of the White Silt bench has been cut up by little streams descending at times from its summit into complicated and ragged ridges. The eroded faces are always very steep and occasionally vertical, and in the sunlight have a peculiar glossy shimmer due to the great abundance of particles of mica, which when the bank is wet become arranged parallel to its surfaces, and on drying adhere in that position. The bedding is generally almost or quite horizontal, and layers of a few inches in thickness succeed one another with great regularity. The deposit is remarkably fine throughout, and no boulders or stones so large as to imply the action of ice were seen.

"These White Silts very often rest directly upon the boulder-clay. They are generally fine and uniform in texture and are usually well bedded in perfectly horizontal layers of 1 to 2 or 3 inches in thickness. Where occasional sandy or gravelly layers are intercalated these are attributable to local causes, being most frequently found opposite the mouths of valleys down which streams have flowed. The silts have evidently been laid down as a rule in tranquil water of considerable depth, and their material has as obviously been supplied by streams or rivers discharging from glaciers not far removed."

From the general correspondence in elevation between this and other deposits in the Cordilleran region and the Red River Valley he draws the conclusion that the inland lake in which these silts were formed was connected with the sea, and "governed in its level by that which the sea held at the time". It does not appear to me that this was so. If it had been, one would expect to find beaches with marine deposits on the coast at much higher levels than that at which they have been found, which does not exceed 200 feet. I think we may find sufficient reason for the formation of a large inland lake which would include the valley of the North Thompson for 100 miles north of Kamloops, and the South Thompson Valley from a short distance below the Little Shuswap Lake to below Spences Bridge, about 125 miles more, with some tributary valleys. This reason is the narrowing of the outlets through high mountain ranges which would result in the blocking of the channel by the meeting of glaciers from the two sides. As to the outlet leading to the Fraser, at Gladwin the 4,000 ft. contour-lines on opposite sides of the Thompson are only 2½ miles apart, and at the 3,000 ft. 1½ miles. Sixteen miles further up the river, near Spences Bridge, the difference is barely 2 miles at the 3,000 ft. level, and less than 3 miles at Pukaist, which is 8 miles higher up. At the 2,500 ft. level they are a mile and a half apart at the first two points and scarcely

over 2 miles at Pukaist. From Spences Bridge to below Gladwin many summits of 5,000 feet and over occur within a mile of the 3,000 ft. level, so that no great stretch of imagination is required to block this outlet with glaciers from the heights above up to the 2,500 ft. level long after they had retired from the more open part of the district. As the river cut down, it must also have been temporarily affected by serious slides in this gorge. Even since white men came to this country the river has been completely blocked on occasions by slides, and was once raised 70 feet. There is another outlet immediately south of Kamloops, where the distance between the two contours at 3,000 feet is 2 miles, and also one leading into it from the head of Cherry Creek, which is less than a mile, but this is above the 2,500 ft. line, and so is the narrower valley of Campbell Creek into which these lead. In this region also there are several high mountains from which local glaciers would descend till a late period.

The main part of the water of this lake would therefore very likely have to find its way eastward by Little Shuswap Lake, whence it would pass through the Greater Shuswap Lake either through the very narrow Eagle Pass, 1,840 ft. elevation, into the Columbia, or in larger quantity into the Okanagen through a pass 1,196 feet above the sea. At several points on its course it would probably be greatly restricted by glaciers from the mountains close by. It would also be considerably impeded at certain seasons by icebergs breaking away from glaciers on the edge of the water, especially in the earlier stages of the recession and stranding of the ice in the channel. These outlets that I have mentioned would have to carry away the water from a district covering about 12,000 miles, and probably the Little Shuswap would be the only one available. It is estimated that the ice covering this region was in many places 6,000 feet thick. Since its general direction was south-eastward, it must have been 5,500 feet thick at Kamloops Lake, as it had to cross a mountain range to the south, which averages over 4,000 feet above the sea. Kamloops Lake level is 1,110 feet elevation at low- and 1,138 at high-water mark.

The time which has elapsed since burial of the skeleton I estimate as follows. I calculate that the silt and gravel which would be deposited in the area now occupied by Kamloops Lake and six miles west, and two miles east of it (comprising with its tributary valleys about 150 square miles), would be drawn from a region extending 35 miles north and 10 miles south, with a length of 25 miles. This would cover 1,125 miles, of which the probable average area covered by glaciers during the period of their retreat would be at least 500 square miles. The area to be filled may for purposes of the calculation be divided into a lower trough below 1,500 feet, a middle stage up to 2,000, and an upper level up to 2,500 feet above sea-level. The lowest would cover 50, the upper 150 square miles.

Basing our calculation on the Muir Glacier discharge as measured by Professor G. F. Wright, of one-third inch over the whole area covered by the glacier annually—

	Years.
One-third inch on 500 square miles would fill lower trough of 50 square miles in 1,800 years, and from just below the 1,200 ft. level in	1,100
One-third inch on 500 square miles would fill the middle stage up to the top and provide sufficient for the deposition of silts in all the sheltered bays up to 2,500 feet in . . .	7,200
Total number of years for deposition of silts since burial of the skeleton	8,300

In making this estimate we must remember that the time would probably be much less: (1) because of frequent slides from the mountains, which would fill many places with local material; (2) because when the great glacier covered all this region and was travelling over high ridges it would naturally tend to leave deposits of boulder-clay at several points in hollows, or in places where on account of the flattening of the grade it could not exert much pushing power, and as the glacier retreated these deposits would be very quickly reassorted by the flooding waters. It appears to me that for these reasons the above figures might well be reduced by 1,500 years.

	Years.
Without making such an allowance, there would have elapsed since the burial of the skeleton	8,300
If we allow 2 feet in ten years as the average rate for the cutting down of the silts when the land began to rise from the 2,500 ft. level to the water-level in Kamloops Lake, the outlet would be reduced to 1,140 feet in less than 6,800 years (high-water mark is 1,138 feet)	6,800
Total number of years since burial	15,100

The rate of cutting down would probably be much greater: (*a*) because silt deposits above 2,000 feet would not be universally distributed; (*b*) on account of the rush of water which would follow the removal of dams in the narrow gorge to the west near Spences Bridge; (*c*) the uplifting of the land, say 1,000 feet; (*d*) the lake has now cut down so low that the grade of the river below it is only 10 feet to the mile, and therefore its excavating power is very small now compared to what it must have been. I should make a further deduction of at least 1,500 feet for these reasons.

The cutting down has not been carried on at an even rate, since it is evident from the appearance of terraces and old shorelines in the valley that the level of the water has at times been almost stationary and at others it has been lowered with a sudden rush, due probably to the breaking of dams and in some part to the elevation of the land. These two deductions would reduce the total to 12,100 years. There is also another possible reduction to be made. These calculations have been founded upon the theory that the whole lower trough of the valley was filled by the silts. There is an argument against this, which is, the peculiarity (referred to by Dr. G. M. Dawson in several papers) that the greater part of Kamloops Lake is evidently a rock basin, 400 to 600 feet deep. If it was once all filled with silts, how could it be excavated? If we assume, however, that the silts were simply deposited in limited areas, each area fed by its own river system, the explanation appears simple. We should then have the silts of the Deadman River extending westward from its mouth and

eastward about 3 miles up the lake, where the water is shallow, except where there is a current which must have been stronger in the past. There would be found further up the Deadman where the stream was more rapid a development of gravel, which is the case, and as the river built up its delta and the glaciers receded, the silts would be laid down farther back on a higher level, as may be seen now near Criss Creek. There would be a small local development of silts at the mouth of Copper Creek at points where there would be but little current, and a large area at the mouth of the Cherry Creek valley and also at the Tranquille River, where there are actually large exposures of the silts at the mouth and contemporaneous gravels higher up (see Dawson's Report, vol. vii, Geol. Survey, as to this last). If this theory be adopted, and it has always seemed to me the correct one, it would explain why some 10 miles of this lake average over 400 feet below the present outlet, which outlet itself is not more than 20 feet above bed-rock showing now in the river below. The only other possible explanation of this hole it that it was excavated by ice, but if so, why did the ice leave the silts untouched at the lower end of the lake? and there is no trace of such ice. Shuswap Lake to the eastward has the same peculiarity, namely, a rock basin with deltas of silt and gravel close to it, showing no silt along its sides except where it might be locally derived. Should this surmise be correct, another 3,000 years might well be taken off the 12,100, leaving only 9,100 years.

To my estimates it will no doubt be objected that they are based on too high estimates of glacier work. It is true that researches such as those of Dolfus Ausset on the Unter Aar Glacier premise a much slower rate of glacial deposit and erosion, but against this there are several arguments. The first is that his observations were drawn from glaciers descending from mountain peaks. Now, the fundamental reason for the existence of a mountain peak is that it is composed of the hardest material in the district. Therefore an estimate of erosion based upon work done under such conditions is certain to be very low, much too low for calculation of the work done by an ice-sheet crossing all kinds of rock-formations. Then, again, to estimate the work of ice-sheets covering hundreds and thousands of square miles by that which is done by glaciers of such limited area is very deceptive. Therefore I put aside his calculation of 0·6 of a millimetre eroded yearly by the Unter Aar Glacier as useless for our purpose.

When we compare the movement of the little glaciers of the Alps with that of the great ones of Greenland we find that while those of Switzerland move at the rate of 3 feet daily, that of Jacobshavn Fiord, 2½ miles wide, moves 60 feet a day according to Helland, and Rink estimated the movement of the Karajek Glacier, 4 miles wide, at 22 to 38 feet daily, and that of others at 24 and 46 feet daily, although he considered that the average motion of glaciers in Greenland was not over 21 feet.

As to the amount of deposition, Helland reported a great variation in Greenland in the amount of glacial mud carried down in suspension by glacial rivers, ranging from 2,374 grammes per cubic metre of

water at Alandgardlek and 678 at Tuaparsuit, down to 104 at Jacobshavn. J. E. Marr (GEOL. MAG., 1887) said that results in Greenland showed a variation from 200 grammes in one river to 9,744 in another.

Great glaciers still exist in British Columbia and Alaska, but are receding rapidly. The Muir Glacier in Alaska when seen by Vancouver in 1794 filled the inlet 25 miles farther down than it does now. I may say that Vancouver's statements and surveys were remarkably correct. The supposition that the recession of the glaciers in this area is comparatively recent is borne out by the fact that the surface disintegration as shown by excavations is practically *nil*. Also, we have some evidence of a rapid fall of the lake-level in old Indian kekwullie houses, which were pits roofed with logs and boughs and then covered with earth. At two points on Kamloops Lake similar huts exist about 70 feet above high water. They are always built as near to water as possible. One of these is at least two hundred yards above the level of the water. But about fifty years ago some were inhabited near the lake as low as 15 feet above high-water mark. There seem to be none between these two stages, suggesting a rapid fall in the water-level.

Regarding my estimate of 10,100 years, I may also note that Warren Upham allows 5,000 years for the erosion of glacial drift and 5,000 years for the Champlain period, which includes the period of retreat of the glaciers. My figures for this would be as above, 9,800. Professor Wright estimates 7,500 years for the streams tributary to Lake Erie to cut their valleys, a work which commenced after the retreat of the glaciers. Professor N. H. Winchell estimated 8,000 years for post-glacial erosion of the Mississippi gorge from Fort Snelling to St. Anthony Falls; G. K. Gilbert 7,000 years for the recession of Niagara Falls, which commenced soon after the close of the Glacial period. Against this must, however, be set the opinion of Dr. J. W. W. Spencer in his exhaustive report on the recession of the falls for the Geological Survey of Canada, in which he estimates 39,000 years as the period required, which he considers might be reduced 3,500 years by admitting Russell's theory of the Erie discharge. If the suggestion advanced by Dr. Pohlmann to the effect that the river re-excavated an old channel from the whirlpool to Queenston were correct this might be further reduced. The writer is not competent to judge as to this, but the retreat of the glacier from the high ranges of the Western Cordillera would probably be much later than in the east. It is generally admitted that the glacial stage of North America endured later than that of Europe.

REVIEWS.

I.—SUBMERGED FORESTS. By CLEMENT REID, F.R.S. 8vo; pp. viii, 129, with 1 plate and 4 text-illustrations. Cambridge: at the University Press, 1913. Price 1*s.* net.

IN this clearly and concisely written little book we are taught the lessons that can be learnt from a careful study of submerged forests by a geologist who is the chief authority on the natural

history of the subject. The occurrence of peaty beds and of stumps of trees that had evidently grown on the area had been observed more than a century ago on the borders of estuaries and of other marshy tracts adjacent to the open sea, as in Lincolnshire. For the most part these exposures afforded no clue to the thickness and character of the strata that are now known to compose the submerged forests, and it is chiefly from the fine sections opened up in excavations for docks that the great interest and importance of these accumulations have been made manifest.

As the author points out, there is no doubt that some portions of marshy areas have subsided through compression and shrinkage of silty and peaty deposits. Again, in some instances alluvial areas that had been protected from the sea by higher portions of the mainland, as in north-western Norfolk, or by accumulations of beach or blown sand, as in the case of Eccles on the north-eastern coast of the county, have been brought within the influence of the sea by the erosion of the barriers or the shifting inland of the sand-dunes. The true submerged forests, however, are those which have undergone a considerable amount of depression, proved when the full thickness of the accumulations has been determined. Judging by the evidence of various excavations and borings, the term is rightly applied to nearly all the submerged forests observed along our coasts. Modern science requires that attention be bestowed not on the mass of the strata, but on each differing layer, so that the sequence of geological events, the fauna and flora, and the objects of archæological interest may be correctly recorded. The evidence supplied by dockyards and borings proves that some 50 or 60 feet of deposits may be grouped with the submerged forests, excluding the most recent marsh deposits and the uppermost estuarine silt or warp known as *Scrobicularia*-clay. Deeper down there are found alternations of peat or peaty soil with roots of trees, and estuarine silt, at three or four successive horizons, the whole often based on estuarine sand and gravel.

The author rightly refers to older deposits of somewhat similar character, such as the Cromer forest-bed of Pliocene age and certain Pleistocene deposits, as at Clacton, to which, however, the term 'submerged forests' is by common usage not applied. In dealing with the submerged forests he gives particulars only of the principal localities where careful detailed evidence has been obtained, as along the Thames Valley at Tilbury. There the channel was cut to a depth of about 60 feet below the modern river-bed, and the maximum elevation of the land is estimated to have been about 80 feet above its present level. Further north, along the eastern coasts, it is noted that in East Norfolk and in the Fenland the ascertained depth of the Alluvial strata with peat-beds is 50 or 60 feet, and in the Humber the channel was about 60 feet deep, as in the case of the Thames. It is remarked that "north of Flamborough Head it seems as though depression gave place to elevation, and when we pass into Scotland the Neolithic deposits seem to be raised beaches instead of submerged forests". Similar evidence is referred to in Scandinavia, Northern Ireland, and the Isle of Man.

Reference is made to the Pleistocene accumulations of the Dogger Bank and to the recent observations of Messrs. H. Whitehead and H. H. Goodchild, who obtained from the Bank loose masses of peat, known to the fishermen as 'moorlog'. Samples of this, examined by Mr. and Mrs. Reid, yielded a highly interesting series of plant-remains, and also of insects which were determined by Mr. G. C. Champion, all of species still living in Britain. The occurrence of this peat indicates a sunken land-surface or submerged forest at a depth below sea of about 60 feet or more. It is remarked that "the lowest submerged land-surface is found in Holland at just about the same depth as it occurs in England, and probably on the Dogger Bank also". Further, it is suggested that on this Bank the Pleistocene deposits may have "formed islands in the ancient fen, as they do now in East Anglia, Holderness, and Holland". It should be noted that the Pleistocene fossils of the Dogger Bank have been known for a longer period than "the last 50 years". In the Geological Magazine for 1878 (p. 443) a figure is given of the lower jaw of a mammoth dredged off the Dogger Bank in 1837.

The evidence of the submerged forests of Lancashire and the Bristol Channel again points to subsidence of about 60 feet, while data obtained in the excavations at the Celtic village of lake-dwellings at Glastonbury are mentioned as indicating that the movement of subsidence ceased "probably not more than 3,500 years ago".

Interesting particulars and conclusions are given respecting the English Channel and the submerged forests generally, in the south of England from Pegwell Bay to Cornwall. Some account is also given of the severance of Great Britain from the Continent. The areas were connected probably in Newer Pliocene times by a low divide, an extension of the Chalk of the North Downs. "Afterwards, during the Glacial epoch, when an ice-sheet accumulated and blocked the northern outlet of the North Sea, the water was ponded back in the southern part. There was no easy outlet northward for the water of the Rhine and other great rivers, so the level of the North Sea rose slightly till it overflowed this low col and cut an outlet where lies the present Strait of Dover." Subsequent elevation obliterated the Strait, and "converted a great part of the North Sea into a wide alluvial plain". When subsidence initiated the formation of the submerged forests the Strait again became an open channel, which has been gradually widened and deepened.

The author points out that much submarine erosion has taken place: that "tidal scour may go on at any depth, provided the current is confined to a narrow channel", and the Atlantic swell may remove coarse sand at depths of at least 50 fathoms. In the English Channel the troughs coincide with lines of tidal scour, and do not usually continue the lines of existing valleys, while the continental platform "is in all probability in the main a feature formed by the deposition of sediment during long ages".

In East Anglia the Norfolk Broads are regarded as directly associated with the subsidence connected with the submerged forests. In the south of England Romney Marsh and Pevensey Level are considered to be submerged flat-bottomed valleys that have been

silted up. Westwards the marshlands bordering the rivers, as near Lewes, afford similar evidence, while Southampton Water, the Solent, and Spithead, with the adjacent harbours, are likewise submerged valleys. In Cornwall and on the Devon borders Plymouth Sound is held to represent a basin once filled with Tertiary and Secondary deposits and subsequently cleared out, the rocky basin having been in part silted up again. The stream-tin deposits belong to a late stage of the Pleistocene period, and were succeeded by the growth of trees and of sundry layers belonging to submerged forests. With regard to the vexed question of the isolation of St. Michael's Mount, the author is of opinion that "as far as can be calculated from its known rate of encroachment, the sea cannot have reached the Mount till long after the Roman period".

In a final chapter the author gives a summary of his conclusions, and points out that his main object has been to suggest directions for further research on a much-neglected subject. All the accumulations of the submerged forests appear to be of Neolithic age. The fauna and flora consist of living British species, with a few mammals since exterminated by man.

The account which we have given of this volume will indicate how carefully the author has considered all aspects of his subject with regard to both fact and opinion. At the same time it may be said that opinions which will be regarded by some geologists as debatable, are not wanting.

In a bibliography the author gives the titles of papers specially bearing on the matters discussed, but as he does not attempt to deal with or even enumerate the many submerged forests that have been described, there is no mention of some geologists like Pengelly, Ussher, and Codrington, who have published important papers on the subject.

II.—Geological Survey Memoir.

The Concealed Coal-field of Yorkshire and Nottinghamshire. By Walcot Gibson, D.Sc. 8vo; pp. vi, 122, with 3 plates and 5 text-illustrations. London: printed for His Majesty's Stationery Office, 1913. Price 1*s.* 6*d.*

THIS is an eminently practical memoir, dealing as it does with the underground extension of the Nottinghamshire, Derbyshire, and Yorkshire Coal-fields, sometimes grouped as the Great Yorkshire Coal-field. The exposed areas of Coal-measures in Nottingham border the Erewash valley in the western part of the county; in Derby they border the western side of that river-valley, extending through Chesterfield to the northern end of the county; thence in Yorkshire the strata are exposed from Sheffield to Leeds. The Magnesian Limestone and other Permian beds cover the eastern portion of the Coal-measures, succeeded by various members of the Trias and sundry superficial deposits. Beneath the Permian and newer deposits Coal-measures have been proved through the greater part of Nottinghamshire, and northwards into the area now known as the East Yorkshire Coal-field, which extends from Doncaster to Thorne and Selby in the Vale of York. This area is shown on the map

(plate i), on which the sites of collieries and boreholes are marked, with the depth to Coal-measures, and other information. It comprises about 1,200 square miles, and the author remarks, in regard to the accessibility of the coals, that the boring at Kelham, near Newark-on-Trent, indicates that the lower seams of the Middle Coal-measures (a division which contains the chief workable seams), "are well within the 4,000-ft. limit of working in Nottinghamshire. In south Yorkshire, from the evidence of the Thorne Boring, it is reasonable to infer that they will seldom exceed this depth, while the Top Hard Coal in Nottinghamshire and Barnsley seam in Yorkshire should be met with under 3,000 feet."

After a general description of the Carboniferous strata, including particulars of the Coal-measures with its coal-seams and fossiliferous horizons, the author passes on to the Permian, Triassic, and superficial deposits, and gives a tabular statement of the thicknesses of these newer formations as proved in various borings from Owthorpe to Selby. A series of vertical sections (plate ii) also illustrates this subject. There is an important chapter on the configuration, structure, and limits of the coal-basin, and the map before mentioned will be found of great use in the study of this part of the subject. On it the contours of the concealed surface of the Coal-measures are indicated, and the approximate depth to these strata, over areas not yet proved, can be ascertained. Diagrammatic sections are also inserted in the text to explain the probable structure of the coal-field.

Detailed records of shafts and borings are given, together with a series of vertical sections (plate iii) to illustrate the Middle Coal-measures above the Top Hard or Barnsley Coal.

The volume thus contains a full account of all that is known of this great and important tract of concealed Coal-measures, the details being tabulated and the problems discussed by one who is a leading authority on the subject.

III.—Hampstead Heath: its Geology and Natural History. Prepared under the auspices of the Hampstead Scientific Society. 8vo; pp. 328, with coloured frontispiece, 10 other plates, and 3 maps. London: T. Fisher Unwin, 1913. Price 10*s.* 6*d.* net.

THIS volume, printed in bold and excellent type on thick but light paper, will justly take a high place among local natural histories, and, as the several contributors show, "Hampstead still offers, considering its nearness to London, considerable scope for the study of nature." This especially applies to the protected area of the Ken Wood Estate.

Of the three maps, one shows the contours of the land, without names of places. Affixed in front of it is a geological sketch-map on transparent paper, showing somewhat roughly the names of principal localities, and the areas occupied by London Clay, Bagshot Sand, Plateau Gravel, Boulder-clay, and Valley Drift. In this map is marked the area under description, which is confined to a radius of 3 miles from the Hampstead Flagstaff. The third map shows the northern portion of Hampstead and part of Finchley, but does not extend over the 3 mile limit.

The section on geology occupies twenty-eight pages, and when we mention that it is written by Mr. F. W. Rudler it is needless to add that it is an admirable essay. An account is given of all the formations above mentioned, including even the 'Claygate Beds', a term recently applied to the passage-beds of sand and loam that bridge over the interval between the mass of stiff London Clay and the mass of overlying Bagshot Sands. Two photographic views are given of the Sands in Ken Wood. The fossils of the London Clay rightly receive a good deal of attention, and a new list is given of species collected from the Hampstead Tube Railway. The minerals of the formations are duly noted, while the subjects of soils, scenery, water-supply, and deep borings are not neglected; nor, we may add, are references to the former resident geologists, N. T. Wetherell and Caleb Evans, and to others who have dealt with the geology of the district.

The section on topography is by Messrs. H. R. Maynard and C. J. B. Findon, while one of the three botanical chapters, that on the vegetation of Hampstead Heath and the neighbouring woods, by Mr. A. G. Tansley, contains references to the soils and substrata, the author observing that "it is essential to understand the geological structure of a district in any attempt to unravel the distribution of the vegetation". In other chapters there are records and descriptions of various forms of animal life, also of pond life in particular, and of climate.

IV.—A Manual of Petrology. By F. P. Mennell, F.G.S., etc. 8vo; pp. 256, with 124 figures in the text. London: Chapman and Hall, Limited. Price 7*s*. 6*d*. net.

THIS book forms an enlarged and improved edition of the author's *Introduction to Petrology*, which was published in 1909. The text has been printed in larger type, and over fifty of the figures, mostly photomicrographs, are new and are a great improvement on those which appeared in the book in its earlier form. The chapters have been re-arranged in more logical sequence, several of them have been rewritten, and tables of analyses have been inserted.

The first three chapters deal with the general and optical properties of rock-forming minerals. Due emphasis is laid on the value of interference figures as aids to the determination of minerals in thin sections. For purposes of description the minerals are classified according to their chemical compositions, instead of by their optical properties. Had they been arranged according to the latter this part of the book would have been more immediately useful in determinative work. The insertion of the actual values of the birefringence for the doubly refracting minerals would have been a great improvement. The simplification of the chemical formulæ for one or two of the minerals has been carried too far. Thus topaz is given as $Al_2O_3 . SiO_2$, thereby failing to show the importance of the hydroxyl and fluorine in its constitution.

The descriptions of the igneous rocks occupy four chapters and though necessarily short they are very much to the point. The nomenclature has been reduced to the simplest form. The rocks are

classified according to their acidity and mode of formation, whereby nineteen divisions are obtained, and the names of these divisions, with suitable prefixes, are made to suffice. The book is written to meet the needs not so much of students as of working geologists, and for such simplicity of nomenclature is a great advantage. Nevertheless, it is very difficult to place many important types in so simple a scheme; thus, borolanite and kentallenite are found under the dolerites, while such well-known groups as the essexites and monzonites do not appear.

There are short chapters on the sedimentary rocks, weathering, the chemistry of rocks, radio-activity, and lastly a useful chapter on the collection of material and the preparation of thin sections.

Chapter ix on the origin and variation of igneous rocks is full of interest, as it contains the author's ideas resulting from a large amount of field work, and in it he states a very strong case for the origin of igneous rocks from 'refusion'. The chapters on the metamorphic rocks also contain much original matter and discussions of many controversial questions.

Throughout the book a great many of the rocks taken as examples are from South African and Australian occurrences, so that the book will doubtless be found most useful by geologists working in those parts of the empire.

V.—The Age of the Earth. By Arthur Holmes. 8vo; pp. xii + 195, with 4 plates, 5 text-figures, and 5 diagrams. London and New York: Harper & Brothers, 1913. Price: cloth, 2*s.* 6*d.* net; leather, 3*s.* 6*d.* net.

THE problem of the age of the earth has occupied the attention of scientists repeatedly since the fourteenth century, and has been a frequent source of keen controversy. This little book has for its aim the criticism, in the light of recent work, of the various methods which have been applied to the solution of the problem. After a brief historical account the several methods are treated in detail.

Kelvin's estimate, based on the effect of tidal retardation on the shape of the earth, is passed over as being based on astronomical theories not generally accepted.

As instances of attempts to connect sedimentation with astronomical data, the work of Croll and of De Geer on the date of the culmination of the Glacial period is quoted. In the same chapter is a review of Gilbert's attempt to connect the regular alternations of limestone and shale in the Upper Cretaceous of Colorado with the position of perihelion.

The work of denudation is considered in the light of the available data for several large rivers, and of Dr. F. W. Clarke's recent estimates of solvent denudation. It is estimated that 9,000 million tons of material are deposited annually on the continental shelves.

The time-worn method of determining the age of the oceans from measurements of the ratio of accumulated sodium to the annual increment is discussed in detail. By introducing numerous corrections it is possible to arrive at ages varying from 80 to 340 million years.

and, as all the corrections are based on insufficient data, it is shown that the method is extremely unreliable.

In the chapter on the relation of sedimentation to geological time the previous estimates based on the thickness of sediments are tabulated. Of these the three most recent, those of Geikie, Joly, and Sollas, vary between 80 and 100 million years. The author points out four further methods by which one arrives at ages varying from 250 to 350 million years, with a possible upper limit of 700 million. It is held that we may be living in an age of more than average sedimentation, in support of which opinion a communication from Professor Chamberlain is quoted.

The author has no confidence in purely geological methods for determining the earth's age. He is, however, enthusiastic on the possibilities brought to light by the study of radio-activity in the rocks, a subject on which he has done much original work.

The accounts of recent research on radio-activity, of the disintegration theory, and of the measurement of radio-activity in rocks, are well written. The work of Joly and Fletcher on pleochroic haloes is reviewed, and it is pointed out that these haloes, after further study, may be used as an indication of the ages of the minerals in which they occur.

The chapter on radio-active minerals is a very important one, giving a lucid account of the refined methods of estimating the age of rocks by determining the ratio of helium to uranium, or of lead to uranium, in the radio-active uranium minerals. The work of Strutt, Boltwood, and Rutherford is described, and the author has also given us the results of some of his own experiments. For Archæan rocks measurements of the 'helium ratio' give an age of 700 million years; measurements of the 'lead ratio', however, give double that figure.

In the last chapter the author reviews all the evidence, and endeavours to show in what directions one must look for a reconciliation between the new and the older methods of determining the age of the earth.

There are two useful appendices, one giving various data referred to in the chapters on radio-activity, the other giving a very complete bibliography of the whole scope of the book.

In the small space at his disposal the author has handled a vast subject in a very able manner.

VI.—Yorkshire Type Ammonites. Edited by S. S. Buckman. The original descriptions reprinted and illustrated by figures of the types reproduced from photographs mainly by J. W. Tutcher. Part ix, 10 plates, with descriptions. London: Wesley, 1913.

WITH this part begins vol. ii of this exceedingly important work. It was long recognized that until some master hand had examined, redescribed, and figured the numerous species of Lias Ammonites from Yorkshire that had been named by Martin Simpson little progress could be made in this fauna. Mr. Buckman essayed the task, and every species that he deals with clears up ground of a most uncertain and treacherous nature. And now that he is well

into the work, it is for palæontologists to see that he is enabled to complete it.

Mr. Buckman's procedure is to print the original diagnosis, to give additional details, and then to discuss and amplify them, recording his result in a final paragraph fixing the nomenclature. Such work is of the highest possible value, for until we have cleared up and fixed old types it is merely beating the air to describe new ones.

We are glad to see that the author tabulates and explains once more his terminology and his zones, as that renders his position and work quite clear and comprehensive.

For Mr. Tutcher's photographs we have nothing but praise. With a critical knowledge of the forms and their details, he has mastered his art, and the combined efforts of the two friends has laid all students of the Ammonites under a great debt. More subscribers are, however, needed to push the work forward to a more rapid completion.

VII.—Brief Notices.

1. Yorkshire Philosophical Society.—The Annual Report of this Society for 1912 contains a notice of the building of a new lecture theatre, erected by the influence of the President, Dr. Tempest Anderson, and formally opened by Professor T. G. Bonney, F.R.S., who delivered a discourse on the "Development of Education".

2. Cambridge Philosophical Society.—To the Proceedings of this Society (vol. xvii, 1913) Mr. R. H. Rastall has contributed notes on "The Mineral Composition of some Cambridgeshire Sands and Gravels", including Plateau and River Gravels and wind-drifted surface-deposits. While the most abundant material in all the sands is naturally quartz, it is interesting to find that "next in abundance is flint in white opaque grains, often well rounded". Other minerals are glauconite, tourmaline, kyanite, staurolite, garnet, hornblende, augite, hypersthene, and epidote, while there is an almost complete absence of muscovite. The author concludes that "the materials have been derived from two sources, partly from the Neocomian sands of Cambridgeshire and the neighbourhood of the Wash, and partly from far-distant sources by ice-transit, that is, from the solid matter transported on and in the ice from Norway, Scotland, and the north of England". In another paper on "The Minerals of some Sands and Gravels near Newmarket" the most notable heavy minerals recorded are zircon and rutile, while kyanite, staurolite, and tourmaline are rare or absent. Moreover, in certain beds of loam and marl muscovite proved to be abundant.

3. South African Vertebrata.—In the *Annals of the South African Museum* (vol. vii, 1912) Dr. R. Broom describes a new species of *Propappus*, and expresses his opinion that this genus and the allied *Pareiasaurus* "were heavily built animals which probably walked with slow, deliberate movements, such as we see in the large tortoises. They were land animals, and it seems more likely that they lived even on the dry land than that they frequented the marshes. The structure of the claws and the humerus would seem to indicate that they were digging animals, and probably, like the *Echidna*, they

defended themselves from their carnivorous enemies by digging into the ground".

In a second paper Dr. Broom describes a species of *Tylosaurus* (a Pythonomorph) from the Upper Cretaceous beds of Pondoland; in a third paper he gives an account of a new type of Cynodont from the Stormberg named *Tritheledon riconoi*, while the new family is called the Tritheledontidæ; and in a fourth paper he discusses some points in the Dicynodont skull.

4. Pleistocene Geology of New York State.—This formed the subject of the annual address to the Geological Society of America, Mr. Herman L. Fairchild, President (Bull. Geol. Soc. Am., xxiv, 1913). The author discusses the limits, thickness, movement, and recession of the ice, its erosional and constructional work together with that of glacial waters in connexion with drumlins, moraines, eskers (sub-glacial), kames (extra-glacial), and other features. In conclusion he refers to Glacial time, remarking that "the estimates of those best qualified to judge of the length of Pleistocene time are from 500,000 to 1,500,000 years".

5. North American Camels.—After six years excavation at La Brea, California, the University of California has been so fortunate as to obtain several nearly perfect skulls of *Camelops hesternus*, and varieties with associated skeletal material representing the greater part of the animal. This has enabled Dr. Merriam to revise all previous work on the group and speak with more certainty as to the many species raised on imperfect material. (Univ. Calif. Publ., Bull. Dept. Geol., vii (14), pp. 305–23, May, 1913.)

6. The Manus of *Trachodon*.—A well-preserved skeleton of *Trachodon marginatus*, Lambe, from the Edmonton formation of the Red Deer River, Alberta, Canada, has allowed Mr. L. M. Lambe to describe the manus in detail. This differs materially from the description given by Barnum Brown of the manus of a specimen from the Lance formation of Wyoming in 1912. That species was called *T. annectens*. About four feet of the tuberculated skin is preserved in the new specimen. Mr. Lambe gives a full account of the manus and three plates in the *Ottawa Naturalist*, May, 1913.

7. Road-metal.—The following paragraph is reprinted from reports for the year 1912, on the Geological Survey, the Geological Museum in Jermyn Street, etc. (P.P., Cd. 6793), 1913: What is essentially a new departure in the work of the Geological Survey of Scotland was made in 1912. The Argyllshire County Council, recognizing the importance of utilizing to the best advantage the great variety of stones suitable for road-metal in that county, desired to purchase a series of road-stone maps showing the occurrence of road-stones in places easily accessible from the main roads. Maps were prepared on the scale of six inches to one mile, on which were marked only the outcrops likely to be of importance for this purpose. The surveyors find them of great use, as the published one-inch maps are on too small a scale to show all the smaller intrusions of igneous rock, some of which make excellent road-stones. As they are not complete maps they are comparatively inexpensive to prepare.

CORRESPONDENCE.

THE DIVISION OF THE UPPER CHALK.

Sir,—Mr. Jukes-Browne's article under this heading in the April number divides itself naturally into two parts, one dealing with the personal aspect, the other (not altogether impersonally) with the scientific aspect.

As for the personal aspect, the position is as follows: Certain observations as to faunal changes within the old zone of *A. quadratus* were judged at the time of the publication of "The Zones of the Chalk in Hants" not to amount to evidence of zonal breaks; they were therefore treated as indicating the existence of subzonal breaks, whose exact position and nature were then not yet ascertained. A large body of further observations enabled me to define the exact position and nature of these breaks and showed that one of them was of zonal importance, involving the proposal of a new zone. Mr. Jukes-Browne announced this intended proposal of mine in such a form that the natural inference was that it was a mere reshuffling of the data already published—the last thing I desired, and forced upon me by some one else's unauthorized version of my unpublished work.

As for the scientific aspect, some of the points originally raised (or which could be raised on his reply) are not of sufficient general interest to justify further elaboration. Of the broader points, what was expressly stated to be a fact concerning the Yorkshire cliffs is now admitted to be an assumption; and the tabulation of records from the old zone of *A. quadratus* in Sussex under the new zone of *O. pilula*, a representation of fact, is now admitted to be based on an assumption which happens to be false, there being at least 100 feet of the restricted zone of *A. quadratus* exposed in the Sussex cliffs. Surely it is not very "captious" to object to these assumptions being presented as established facts. Mr. Jukes-Browne was *not* told by me that he "had no right" to make the assumption as to Yorkshire. He is entitled to make any assumption; his grounds for making it are then a legitimate subject of criticism.

Several broad points seem to go by default, e.g. that the highest Yorkshire chalk is so far North-German in its apparent affinities that its nomenclature should be North-German rather than Anglo-Parisian, and its fossils should not be mixed up with those of the Anglo-Parisian chalk of Sussex; or again, that records from Yorkshire, where no chalk of the restricted zone of *A. quadratus* is admitted to be preserved, cannot logically be used to prove the absence of certain species in that epoch. If this were logical it could be proved that in Kent all the common fossils of the Chalk died out in the zone of *Marsupites*.

Mr. Jukes-Browne now writes of a "Yorkshire zone of *A. granulatus*", a zone quite novel to me. It would be interesting to know where to find a definition of this zone and how it is distinguished from the zone of *O. pilula* or *Scaphites binodosus*, or again, from Dr. Rowe's "local zone of *Inoceramus lingua*".

Mr. Jukes-Browne's challenge to me to prove that *A. granulatus* does occur in the restricted zone of *A. quadratus* is really irrelevant.

I have not stated that *A. granulatus* does occur there, and if I could not point to an undoubted *A. granulatus* from a horizon at which any Belemnites are most exceptional occurrences it would not prove that *A. granulatus* never occurs there, as assumed by Mr. Jukes-Browne. It so happens that the challenge can be met out of his own mouth. He says: "With respect to Sussex I relied on the published records, according to which . . . in the cliffs between Seaford and Brighton . . . *A. granulatus* occurred through at least the lower 150 feet." As the zone of *O. pilula* is only from 100 to 110 feet thick in the Sussex cliffs (and does not exceed 105 feet at Seaford), *A. granulatus* at 150 feet must be well up in the restricted zone of *A. quadratus*. Specimens of *A. granulatus* occurring at 120 feet would be equally, though less deeply, in the restricted zone of *A. quadratus*.

R. M. Brydone.

27 Twyford Mansions, W.

THE LEICESTERSHIRE AND SOUTH DERBYSHIRE COAL-FIELD.

Sir,—I shall be much obliged if any readers of the Geological Magazine can inform me of the whereabouts of a collection of Coal-measure fossils, chiefly plants, made by Edward Mammatt, author of *Geological Facts*. He was the first man, as a pupil of William Smith, to put into practice for Carboniferous zonal work the principle that strata are characterized by their organic remains. A detailed coloured section is given in his work, with the position of fossils found indicated. Moreover, these fossils are figured in his work, but unfortunately in the state of lithography at that time accuracy was not possible, and it would be necessary to examine the originals in many cases to be sure what fossil is intended. So valuable is this record, since the sections are now bricked in, that the information the fossils could afford would be of the greatest assistance to me in further working out the palæontology of this coal-field. Mammatt was a friend of the late Professor A. H. Green, who surveyed part of the district, afterwards going to Oxford.

Inquiries were made amongst several colleagues when my preliminary account of this coal-field was communicated to the Survey memoir on this coal-field, published in 1907, but I was then unable to obtain any information. Since I am hoping to revise this account, which was drawn up before the work had gone very far, and as I have a good deal of additional information, any facts of importance that may be known to readers of this Magazine will be cordially welcomed.

When the above-mentioned account was written, reliance had to be placed upon certain data which may, after a fuller study of the question, have to be read in a new light, in spite of the fact that my friend the late Mr. Fox-Strangways and I were satisfied with them at the time. It is in this connexion that Mammatt's sections are specially interesting.—Yours truly,

A. R. Horwood.

Leicester Museum.
July 9, 1913.

OBITUARY.

SIR JONATHAN HUTCHINSON, KT., F.R.C.S., M.D., LL.D., F.R.S.

BORN JULY 23, 1828. DIED JUNE, 1913.

IN Sir Jonathan Hutchinson there has just passed away in his 85th year an eminent physician, a Fellow and (in 1889 and 1890) Hunterian Professor of the Royal College of Surgeons, most distinguished as a specialist in diseases of the skin; elected a Fellow of the Royal Society (1882); one of the most kindly and unselfish of men, ever ready to do good to others. Outside the medical profession —to which he devoted a long and laborious life, and spent much money and time in advancing—his pet idea was that the establishment of small local museums, scattered about the country, would be of the greatest value as aids to education. He himself established and supported two such, one at Selby in Yorkshire (his birthplace) and the other at Haslemere, at which latter place was his home,[1] and where he retired after a long and strenuous career as a medical man.

Although intensely interested in geology, he could from his well-stored mind address an audience on a great variety of subjects, and was never so happy as when lecturing to a roomful of country people or to young folks. The pleasure of imparting information to others was only equalled by the eagerness with which he sought and acquired knowledge. History, poetry, archæology, botany, and geology all in turn attracted his attention and were studied with care. Even when 73 years of age, he travelled thousands of miles in India and Cape Colony in pursuit of his investigation into the cause and origin of leprosy, eager to help to relieve the sufferers and, if possible, to cure them. Like his colleague Sir Joseph Lister (both members of the Society of Friends), Jonathan Hutchinson leaves behind him the record of a life devoted to the welfare of his fellow-men and the relief of human suffering.

DR. P. LUTLEY SCLATER, M.A., F.R.S.

BORN NOVEMBER 4, 1829. DIED JUNE 27, 1913.

WE much regret to record the death of Philip Lutley Sclater, M.A., D.Sc., Ph.D., F.R.S., F.L.S., F.G.S., F.R.G.S., Hon. Fellow of Corpus Christi College, Oxford, at his country seat, Odiham Priory, Winchfield, Hampshire, at the advanced age of 84. He was the second son of William Lutley Sclater (his elder brother being the Right Hon. G. Sclater-Booth, afterwards Lord Basing). He was educated at Twyford and Winchester, where he obtained a scholarship at Corpus, and took his degree and a first in mathematics at Oxford in 1849, remaining there two years afterwards. Later Dr. Sclater entered Lincoln's Inn, and was called to the Bar in 1855. Under the influence of Strickland he took up ornithology, and spent some years in travelling in Italy, Sicily, Canada, and the United States. Later on he visited Morocco, Egypt, South Africa, and the West Indies.

[1] The Library, Inval, Haslemere.

He was one of the founders of the British Ornithologists' Union, and was editor of the *Ibis* for over fifty years. He contributed several bird-catalogues to the British Museum, and was recognized as one of the leaders of systematic zoology. He became a Fellow of the Zoological Society in 1850 and was elected Secretary in 1859, which office he held until 1902 (a period of forty-three years), when he retired on a pension. He was deeply interested in the scientific side of zoology, and largely promoted the publication of the *Zoological Record* (founded in 1864), which he induced the Zoological Society to aid by an annual grant and to be wholly responsible for from 1866 to nearly the present time.

Dr. Sclater was also keenly interested in promoting the carrying on of the *Index Generum et Specierum Animalium*, by Mr. Charles Davies Sherborn, F.G.S., F.Z.S., which was commenced by the author in July, 1890, and is *still in progress*—a stupendous undertaking to be carried out by the labour of one man. At the date of the first notice (Proc. Zool. Soc., 1896, p. 610) 130,000 slips had already been stored away in alphabetical order (see GEOL. MAG., 1896, pp. 557–61). The first volume of this famous work, which occupied eight years in its production, was issued in 1902 by the Cambridge University Press, and embraced all names from January 1, 1758, to December, 1800, and contains 61,600 entries. The work, under the support of a committee, has been continued, and each year its author has issued a report of progress. The slips are stored in the Natural History Museum, where they are always accessible to all workers in zoology.

As regards the continuation of this important undertaking, Dr. Sclater had the pleasing satisfaction to know in April of last year (1912) that the Trustees of the British Museum had resolved to take over the work of the compilation of the *Index Animalium*, and had given Mr. Sherborn rank as a "Special Assistant" on the staff of the British Museum (Natural History).

One who knew Philip Lutley Sclater well writes: "The death of Dr. Sclater deprives many of a real friend, and science in general of a warm supporter. A zoologist primarily, he yet found time to take an interest in geology, and was ever ready to learn what geology had to teach in the elucidation of questions of geographical distribution and evolution. As Secretary to the Zoological Society he had often led parties of geologists around the Gardens."

We cannot conclude this brief notice of Dr. Sclater's valuable services to science without a passing reference to his important contribution to the study of the geographical distribution of animals.

In 1858 [1] he discussed the primary zoological divisions of the earth, taking birds as the basis, and designated six great regions, which he named the Palæarctic, Æthiopian, Indian, Australian, Nearctic, and Neotropical. Although the general tendency at present is to unite several of these regions together, they nevertheless have proved of great service to palæozoologists in dealing with the broad questions of geographical distribution of animals in the past, and it is interesting to find how far Dr. Sclater's studies in zoology had advanced our

[1] Journ. Proc. Linn. Soc. (Zoology), vol. ii, pp. 130–45 (1858).